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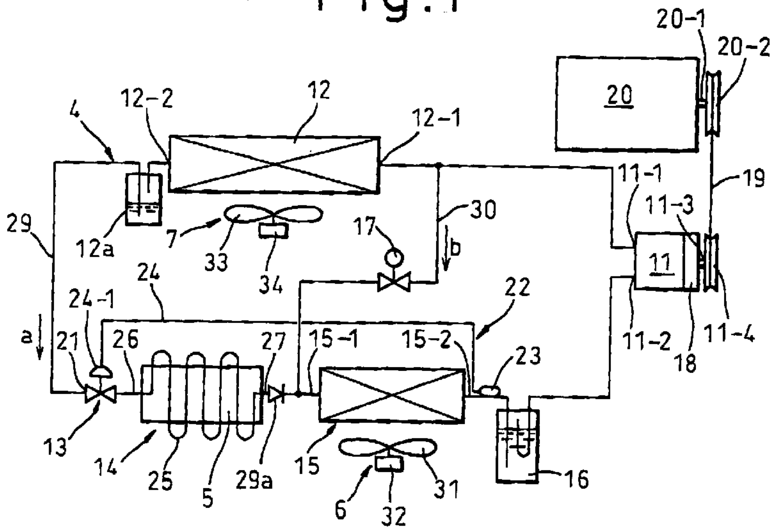
(54) Refrigerating system

(57) A refrigerating system having a cool storage evaporator 14 and a refrigerating evaporator 15 arranged in series. The cool storage evaporator 14 includes a rounded cross sectioned tube 25 which is in contact with a cool storage material stored in containers. The cool storage material has a melting temperature which substantially corresponds to a predetermined value of evaporating temperature of a refrigerant when the temperature inside a refrigerating compartment is reduced to a predetermined value for switching from a refrigerating operation to a cool storage operation. During the refrigerating operation, the cool storage material is prevented from being frozen, thereby preventing a load to the cool storage material. During a cool storage operation obtained by stopping the operation of an inner fan 31, a throttling of a temperature operated expansion valve 13 maintains desired temperature difference between the temperature of the cool storage material and an evaporating temperature of the refrigerant at the cool storage evaporator 14.

Fig.1



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Description

The present invention relates to a refrigerating system and more particularly to a refrigerating system for a refrigerating compartment for a refrigerated vehicle, which system includes an evaporator for a cool storage area and an evaporator for a refrigeration area.

Known in a prior art is a refrigerating system for a refrigerated vehicle with a cool storage capability, as disclosed in Japanese Unexamined Patent Publication No. 64-6654, which apparatus includes a refrigerating device for executing a refrigerating cycle, an outer blower and an inner blower. The refrigerating unit includes a compressor, a condenser, temperature responsive automated expansion valves, an evaporator for a refrigeration area, an evaporator for a cool storage area, and a gas-liquid separator or accumulator. The first temperature responsive automated valve has a diaphragm opened to a temperature sensitive tube at an outlet of the refrigerating evaporator via a capillary conduit, so that the size of an orifice, i.e., the pressure amount of the refrigerant introduced into the gas/liquid separator, is controlled in accordance with the temperature of the refrigerant at the outlet of the evaporator. Similarly, the second temperature responsive automated valve has, also, a diaphragm opened to a temperature sensitive tube at an outlet of the cool evaporator via a capillary conduit, so that the size of an orifice, i.e., the pressure amount of the refrigerant introduced into the gas/liquid separator, is controlled in accordance with the temperature of the refrigerant at the outlet of the cool storage evaporator. The refrigerating evaporator and the cool storage evaporator are arranged in parallel. The prior art refrigerating system is further provided with switching valves, which are repeatedly and intermittently operated between open and closed conditions, so as to obtain a refrigerating operation and a cool storage operation. When the engine is stopped or an output power of the engine is insufficient for obtaining a desired rotational speed due to the running of the automobile in a traffic jam, the cool storage material in the cool storage evaporator melts, which is effective for maintaining a desired low temperature inside the refrigerating compartment.

As explained above, the repeated opening or closing operation of the switching valves in the prior art (Japanese Unexamined Patent Publication No. 64-6654) allows the refrigerating operation and the cool storage operation to be effectively executed. However, the parallel arrangement of the refrigerating evaporator and the cool storage evaporator necessitates two thermo-sensitive automated operation valves as well as two switching valves, which causes the number of the parts to be increased, thereby increasing the production cost. Furthermore, in the prior art construction, during the cool storage operation, melting of the cool storage material is commenced from its outer portion, which can easily contact the air in the refrigerating compartment. In other words, melting of the cool storage material located at the inner side adjacent to the tube of the cool storage evaporator is less likely. As a result, effective use of the latent heat of fusion of the cool storage material cannot be obtained.

An object of the present invention is to provide a refrigerating system of a reduced cost capable of obtaining a refrigerating operation as well as a cool storage operation, which are effective.

Another object of the present invention is to provide a refrigerating system capable of preventing the cool storage material from being melted during a de-frosting operation.

Still another object of the present invention is to provide a refrigerating system capable of obtaining an effective refrigerating operation while obtaining an increased performance during a cool-down operation.

Further another object of the present invention is to provide a refrigerating system capable of preventing a cool keeping operation from being affected by increasing the heat absorbing performance of the refrigerant at the cool storage evaporator.

Still further object of the present invention is to provide a refrigerating system capable of obtaining an increased cooling performance at an initial phase after a cool storage operation.

According to the present invention, a refrigerating system is provided which comprises:

a heat insulated chamber;

means for generating a flow of air recirculated in the chamber;

means arranged in the chamber for holding an amount of cool storage material;

a compressor for compression of a refrigerant;

a condenser for receiving the compressed refrigerant from the compressor;

an expansion valve for reducing the pressure of the refrigerant from the condenser;

a first evaporator for receiving the refrigerant of the reduced pressure for cooling the cool storage material;

a second evaporator for receiving the refrigerant of the reduced pressure for cooling the air flow recirculated in the chamber;

a closed passageway for the refrigerant being constructed by the compressor, the condenser, the temperature sensitive expansion valve, the first evaporator and the second evaporator;

said expansion valve being of a type capable of controlling the amount of the recirculated refrigerant in accordance with the temperature of the refrigerant at an outlet side of the second evaporator;

said first and second evaporators being arranged in series with each other;

the expansion valve being arranged in the closed passageway at a location upstream from the evaporators, and;

means for obtaining switching between a refrigerating condition where the flow of the recirculated air by means of the air flow generating means is obtained and a cool storage condition where the flow of the recirculated air by means of the air flow generating means is cancelled. Due to the series arrangement of the cool storage evaporator and the refrigerating system, a reduction of cost is obtained because of a reduced number of the parts, while maintaining an effective refrigerating operation as well as an effective cool storage operation.

Advantageously, the refrigerating system further comprises, in addition to the closed passageway, an additional passageway for connecting the recirculating passageway at a location between the compressor and the condenser with the recirculating passageway at a location between the first and second evaporators, and a switching means for obtaining switching between a first condition where the flow of the refrigerant along the closed passageway, i.e., the refrigerant from the compressor is passed through the condenser, the expansion valve and the first evaporator and is introduced into the second evaporator, and a second condition where the refrigerant from the compressor is passed through the additional passageway and is introduced into the second evaporator, i.e., by-passing the cool storage evaporator. The by-passing of the cool storage evaporator during the second condition can obtain a de-frosting operation, while preventing the cool storage material in the cool storage evaporator from melting.

Advantageously, said temperature sensitive expansion valve comprises a first variable orifice in the recirculating passageway, a second variable orifice located downstream from the first orifice, and an actuator responsive to the temperature of the refrigerant at the outlet of the evaporators for controlling the first and second orifices in such a manner that, during the cool storage operation, an adiabatic expansion of the refrigerant occurs at the first orifice, while, during the refrigerating operation, an adiabatic expansion of the refrigerant occurs at the second orifice. During the refrigerating operation, a large amount of the recirculated refrigerant, suitable for the high load operation, is obtained, thereby maintaining a desired performance during a cool-down operation. During the cool storage operation (a low load operation), the second orifice can operate within a range where the degree of the superheating is controlled, thereby preventing hunting from occurring.

Advantageously, the refrigerating system further comprises sensor means for detecting the temperature inside the chamber, and means for controlling the air flow generating means in such a manner that an increased amount of the air flow is obtained when the temperature inside the chamber is higher than a predetermined value during the refrigerating operation. As a result, an increase in the cooling capacity is obtained at the initial stage of the cool storage or refrigerating operation due to the fact the cool storage material is melted. In this case, an increase in the evaporating temperature at the refrigerating evaporator cause the melting of the cool storage material to be commenced at a region adjacent the cool storage evaporator. As a result, an effective use of the latent heat of melting of the cool storage material is realized.

According to the present invention, a refrigerating system is provided, comprising:

a heat insulated chamber;

means for generating a flow of air recirculated in the chamber;

means arranged in the chamber for holding an amount of cool storage material, and;

a refrigerating recirculating unit including a compressor for compression of a refrigerant, a condenser for receiving the compressed refrigerant from the compressor, an expansion valve for reducing the pressure of the refrigerant from the condenser, a first evaporator for receiving the refrigerant at the reduced pressure for cooling the cool storage material, and a second evaporator for receiving the refrigerant of the reduced pressure for cooling the air flow recirculated in the chamber, a closed passageway for the refrigerant being constructed by the compressor, the condenser, the temperature sensitive expansion valve, the first evaporator and the second evaporator, said expansion valve being of a type capable of controlling the amount of the recirculated refrigerant in accordance with the temperature of the refrigerant at an outlet side of the second evaporator;

said cool storage evaporator comprising a plurality of packs, each of which includes a container for storing therein a cool storage material, and a tube of a serpentine arrangement which is located in the refrigerant recirculated passageway and which is in contact with the cool storage material.

Advantageously, said serpentine tube include portions projected out of and located below said packs. The projected portion functions as a heat pipe, thereby improving the cooling of the air inside the chamber.

An embodiment of the present invention will be explained with reference to attached drawings in which:

Fig. 1 is a schematic view of a refrigerating system according to the present invention.
Fig. 2 is a perspective view of a refrigerated vehicle including the refrigerating system in Fig. 1.
Fig. 3 is a perspective view of a cool storage evaporator in the refrigerating system in Fig. 1.
Fig. 4 is a diagrammatic view of a control circuit in the refrigerating system in Fig. 1.
Fig. 5 is a flow chart illustrating an operation of the control circuit in Fig. 4.
Figs. 6A to 6E are timing charts illustrating an operation of the control circuit in Fig. 4.
Fig. 7 is a plan view, partially exploded, of a cool storage evaporator in a second embodiment.
Fig. 8 is a plan view, partially exploded, of a cool storage evaporator in a third embodiment.
Fig. 9 is a cross sectional view of a temperature sensitive expansion valve in a fourth embodiment.
Fig. 10 is similar to Fig. 9 but illustrating it under a low load (cool storage) operation.

Fig. 11 shows the relationship between the degree of the opening of the expansion valve and a recirculated amount of the refrigerant.

Fig. 12 is similar to Fig. 1 but illustrates a fifth embodiment.

Fig. 13 is a cross sectional view of the electromagnetic valve in Fig. 12.

Fig. 14 is a cross sectional view of a temperature sensitive expansion valve in a sixth embodiment.

Fig. 15 is similar to Fig. 14 but shows it under a high load (refrigerating) operation.

Fig. 16 is a cross sectional view of a refrigerated vehicle in a seventh embodiment.

Fig. 17 is a partially enlarged view of a cool storage evaporator in Fig. 16.

Fig. 18 is relationship between the time lapse after the start of a refrigerating operation and a inside temperature change in the seventh embodiment.

Fig. 19 is a perspective view, partially exploded, of a cool storage evaporator in an eighth embodiment.

Fig. 20 is a perspective view fully exploded of a cool storage evaporator in a ninth embodiment.

Fig. 21 is a cross sectional view of the cool storage evaporator in a ninth embodiment.

Fig. 22 is similar to Fig. 21 but illustrates it under a high load condition.

Fig. 23 is a diagrammatic view of a control circuit in tenth embodiment.

Fig. 24 is a flow chart illustrating an operation of the tenth embodiment.

Fig. 25 shows, in tenth embodiment, Mollier diagrams at a refrigerating operation (a), a cool storage operation (b) and a cool down operation (c), respectively.

A first embodiment of the present invention will be explained with reference to Figs. 1 to 6. Fig. 1 shows a construction of a refrigerating system for a refrigerated vehicle, while Fig. 2 shows the refrigerated vehicle to which the refrigerating system in Fig. 1 is attached. In Fig. 2, the refrigerated vehicle 2 is provided with a refrigerating system 1. As shown in Fig. 1, the refrigerating system 1 includes a refrigerating compartment 3, a refrigerating unit 4 with a cool storage device for cooling the refrigerating compartment 3, an inside blower 6 located inside the refrigerating compartment 3, and outside blower 7 located outside the refrigerating compartment 3, and a control panel 8 in which control circuitry is housed for controlling the energization of the various parts of the system 1.

The refrigerating compartment 3 is formed with a thermally insulated construction. Namely, the refrigerating compartment 3 is connected to a body of the refrigerated vehicle 2, and is formed as a box of a rectangular parallelepiped shape formed from a heat insulating material having a chamber therein for storing frozen or refrigerated foods. In a well known manner, the refrigerating compartment 3 is provided with a door 2-1 at the rear side thereof.

In Fig. 1, the refrigerating unit 4 for executing the refrigerating cycle includes a refrigerant compressor 11, a refrigerant condenser 12, a receiver 12a, a temperature operated automatic valve 13, a cool storage evaporator 14, a refrigerating evaporator 15, an accumulator 16 and a refrigerant flow switching valve 17. Furthermore, pipes are provided for connecting theses components with each other so that a refrigerating cycle is executed. Namely, the compressor 11 has an outlet 11-1 connected to an inlet 12-1 of the condenser 12. The condenser 12 has an outlet 12-2 connected to the receiver 12a. The receiver 12a is connected, via the temperature operated automatic valve 13, to an inlet 26 of the cool storage evaporator 14. The cool storage evaporator 14 has an outlet 27 connected to an inlet 15-1 of the refrigerating evaporator 15. The refrigerating evaporator 15 has an outlet 15-2 connected, via the accumulator 16, to an inlet 11-2 of the compressor 11.

A reference numeral 20 denotes an internal combustion engine of the refrigerated vehicle 2, and has a crankshaft 20-1, on which a pulley 20-2 is connected. The compressor 11 has a rotating shaft 11-3 and a pulley 11-4 on the shaft 11-3. A belt 19 is provided for obtaining a kinematic connection between the pulleys 20-2 and 11-4. Furthermore, the pulley 11-4 is connected to a clutch 18 for selective transmission of a rotating movement of the pulley 11-4 to the compressor 11. As a result, an engagement of the clutch 18 causes the compressor 11 to be operated for executing a compression operation. As a result, the gaseous refrigerant sucked from the inlet 11-2 is subjected to a compression, and the compressed gas at a higher temperature and pressure is discharged from the outlet 11-1. In place of the compressor 11 operated by the internal combustion engine 20, an electrically operated compressor, the rotational speed of which is controlled by an inverter, can be employed. Furthermore, the compressor may be of a type of a variable outlet amount.

The refrigerant condenser 12 is arranged at a desired location of the refrigerated vehicle 2, where an outside air flow, generated by the movement of the vehicle, is effectively contacted, i.e., at a bottom location of the refrigerating compartment 3 as shown in Fig. 2. At the condenser 12, the gaseous refrigerant of high temperature and pressure from the compressor 11 is subjected to a heat exchange with the outside air flow generated by the outside blower 7 and the air flow generated by the movement of the refrigerated vehicle 2. As a result, the gaseous refrigerant is liquidized and is introduced into the receiver 12a, where the liquid state refrigerant is separated. It should be noted that the receiver 12a can be eliminated in case where a complete liquidation occurs at the condenser 11.

The temperature-sensitive automated valve 13 as an expansion valve is constructed by a valve member 21 as a throttle valve and a temperature sensing unit 22 for operating the valve member 21. Namely, the valve member 21 forms a throttled orifice (not shown) for ejecting the refrigerant from the condenser 12, so that the refrigerant is subjected to an expansion, thereby obtaining a gas-liquid combined state of the refrigerant at a low temperature and pressure.

The temperature sensitive unit 22 includes, in a well known manner, a temperature sensitive tube 23, a operating member 24-1 such as a diaphragm actuator, and a capillary tube 24 having a first end opened to the space inside the temperature sensitive tube 23 and a second end opened to the diaphragm 24-1. Inside the temperature sensitive tube 23, a gas having the same components as the refrigerant is sealingly stored, so that the pressure of the gas in the temperature sensitive tube 23 corresponds to a degree of a superheat of the gaseous refrigerant sucked into the compressor, which corresponds to the change in the temperature of the refrigerant at the outlet of the refrigerating evaporator 15. The term "superheat" means an increase in a temperature (enthalpy) after a equibrium state is established during an evaporating phase in a refrigerating cycle. By way of the capillary tube 24, the pressure in the temperature sensitive tube 23 is opened to the diaphragm 24-1, so that the valve 21 controls the degree of the throttle in accordance with the pressure change. Namely, in the operation of the temperature sensing unit 22, an increase in the temperature of the refrigerant at the outlet of the refrigerating evaporator 15 causes the gas in the pressure sensitive tube to expand, so that the operating unit 24-1 causes the valve 21 to be moved in a direction to increase a flow area thereby increasing the amount of the recirculated refrigerant, which causes the temperature of the refrigerant to be decreased. Contrary to this, a decrease in the temperature of the refrigerant at the outlet of the refrigerating evaporator 15 causes the gas in the pressure sensitive tube to be compressed, so that the operating unit 24-1 causes the valve 21 to be moved in a direction to decrease a flow area, thereby reducing the amount of the recirculated refrigerant, which causes the temperature of the refrigerant to be increased.

Fig. 3 illustrates a construction of the cool storage evaporator 14, which is located in the refrigerating compartment 3 at its top portion as shown in Fig. 2. As shown in Fig. 1, the cool storage evaporator 14 is, in the refrigerating circuit, located at a position upstream from the refrigerating evaporator 15. In the cool storage evaporator 14, a heat exchange occurs between the gaseous-liquid combined state refrigerant and the cool storage material, so that the cool storage material is cooled, on one hand, and the refrigerant is evaporated to a gaseous state, on the other hand. In the first embodiment, the cool storage evaporator 14 is, as shown in Fig. 3, constructed by a plurality of packs 5 as a container made of a resin material of a good heat conductivity for filling therein a cool storage material, and a tube 25 of a rounded cross sectional shape made from a metal material of a good heat conductivity. The tube 25 has an inlet 26 for connection with the thermo-sensitive valve 13 for receiving the refrigerant therefrom, and an outlet 27 for discharging the refrigerant to the refrigerating evaporator 15. The refrigerant tube 25 is formed as a serpentine shape which is constructed by a straight portions 25-1 spaced in parallel and curved portions 25-2 connecting the straight portions 25-1 with each other. Laterally two adjacent vertical rows of pairs of packs 5 are provided. In each pair, two adjacent straight portions are arranged between the packs 5. The refrigerant from the condenser 12 is passed through the tube 25, so as to cool the cool storage material.

In place of the circular tube 25, a flattened refrigerant tube can be employed for increasing a heat exchanging surface area for increasing the refrigerating capacity. Furthermore, on the outer surface of the circular tube 25, fins can be provided for increasing the heat exchanging capacity.

In the cool storage packs 5, a cool storage material is stored, such as a brine (a water solution of calcium chloride or sodium chloride et al.), or methanol water brine. In the illustrated embodiment, a cool storage material is used, which has a soldifing temperature or a melting temperature of, for example, -25°C, which is similar to the evaporating temperature of the refrigerant of, for example, -25°C of the refrigerating evaporator 15, when the temperature of the refrigerating compartment 2 is reached to a first predetermined temperature of, for example, -20°C.

When the refrigerating system 4 is out of operation, i.e., the clutch 18 in the pulley 11-4 is de-energized for disconnecting the compressor 11 from the rotating movement of the engine crankshaft 20-1, the cool storage material is melted, thereby maintaining a low temperature of the chamber inside the refrigerating compartment 3. In other words, latent heat, which is adsorbed when the cool storage material is melted, deprives heat from the refrigerating compartment 3, thereby maintaining a cooled condition of the refrigerating compartment. In the illustrated embodiment, the soldifing or melting temperature of the cool storage material is -25°C. However, an adjustment of the soldifing or melting temperature of the cool storage material is possible by varying the amount of the solute such as salt in a solvent such as a water of a fixed amount, or a set temperature at the refrigerating compartment 3.

The refrigerating evaporator 15 is arranged in a duct of a cooling unit 28 arranged at a top side of the refrigerating compartment 3, and is, in a well known manner, constructed as a stacked type heat exchanging device which is constructed by a pair of spaced tanks, a stack of heat exchanging tubes extending between the tanks and fins on the outer surfaces of the heat exchanging tubes. In the refrigerating evaporator 15, a heat exchange occurs between an inflow of refrigerant from the cool storage evaporator and a flow of an inner air generated by the inner blower 6, so that the refrigerant is evaporated.

The accumulator 16 is for separating the refrigerant from the refrigerating evaporator 15 into a liquid phase and a gaseous phase, and for discharging only the gaseous phase refrigerant into the compressor 11.

As shown in Fig. 1, the flow switching valve 17 as an electromagnetic valve is arranged on a hot by-pass passageway 30 having one end connected to a recirculating pipe between the outlet 11-1 of the compressor 11 and the inlet 12-1 of the condenser 12. The flow switching valve 17 is switched between a closed position where a normal flow of the refrigerant is obtained via the condenser 12, the receiver 12a, a recirculation pipe 29, the cool storage evaporator 14 and a check valve 29a, and an opened position where a by-passed flow of the refrigerant is obtained via the by-pass passageway 30. Namely, when the switching valve 17 is in the closed position, the passageway 29 allows the refrigerant to pass through the condenser 12, the receiver 12a as shown by an arrow a, the expansion valve 13, and the cool storage evaporator 14. When the switching valve 17 is in the opened position, the passageway 30 allows the refrigerant to be directly introduce into the refrigerating evaporator 15, as shown by an arrow b, i.e. to by-pass the condenser 12, the receiver 12a, the expansion valve 13, and the cool storage evaporator 14, thereby executing a defrosting operation. In the by-pass condition, the check valve 29a prevents the refrigerant from being reversed.

The inner blower 6 is constructed by a inner fan 31 for generating an air flow in the duct of the cooling unit 28 and an electric motor 32 for generating a rotating movement applied to the inner fan 31. In a well known manner, a bearing means is provided for rotatably connecting the fan 31 to the duct of the cooling unit 28. The fan 31, when the rotating movement from the electric motor 32 is applied, sucks the inner air in the refrigerating compartment 3 into the duct of the cooling unit 28 as shown by an arrow f1, so that the air flow is directed to the refrigerating evaporator 15 arranged in the duct. As a result, a heat exchange is occurred at the evaporator 15 between the refrigerant and the air flow, which causes the air flow is cooled. The thus cooled air is, after contacting the cool storage evaporator 14, discharged to the space inside the refrigerating compartment 3, as shown by an arrow f2. As shown in Fig. 2, a control panel 8 is arranged inside the refrigerating compartment 3 for controlling the operation of the inner fan motor 32. In a well known manner, the electric motor 32 can be provided with a means for obtaining two or more steps of control, or a stepless control, of the motor 32.

The outside blower 7 is, as shown in Fig. 1, constructed by an outer fan 33 for generating an outside air flow contacting with the refrigerant condenser 12 and an outer fan motor 34 for generating a rotating movement applied to the outer fan 33. The outer fan 33 is located adjacent to the condenser 12. The outer fan motor 34 is also controlled by the control panel 8, so that the fan motor 34 is selectively operated. It is also possible to construct the control panel 8 such that two or more steps of control, or a stepless control, of the motor 32 is obtained in order to adjust the amount of the air flow generated by the outside fan 33.

Fig. 4 shows, schematically, a construction of the control panel which is constructed as a microcomputer system including, in a well known manner, a central processing unit (CPU), a read only memory (ROM), a random access memory (RAM) and a timer circuit (clock signal generator). In a well known manner, various switches, setters and sensors are connected to the control panel 8, such as a switch 8-1 for making the refrigerating system operate, a switch 8-2 for obtaining a desired setting of a temperature inside the refrigerating compartment 3, a de-frosting switch 8-3, a sensor 37 for detecting an actual temperature inside the refrigerating compartment 3, and a sensor for detecting a temperature of the cool storage material.

Relay coils 39 to 42 are also connected to the control panel 8. The relay coil 39 has a contact 43 for controlling an on-off operation of the clutch 18. The relay coil 40 has a contact 44 for controlling an on-off operation of the refrigerant flow switching valve 17. The relay coil 41 has a contact 45 for controlling an on-off operation of the inner fan motor 32. The relay coil 42 has a contact 46 for controlling an on-off operation of the outer fan motor 34. The control panel 8 responds to signals from the operating switch 8-1, the inner temperature set switch 8-2, the de-frosting switch 8-3, the inner temperature sensor 37 and the cool storage material temperature censor 38 so that the relay coils 39 to 42 are selectively energized in such a manner that a desired manner of operations of the clutch 18, the refrigerant flow switching valve 17, the inner fan motor 32 and the outer fan motor 34 is obtained, as will be fully described later.

Namely, the operation switch 8-1 commences a refrigerating operation as well as a cool storage operation of the refrigerating system 4. When the operating switch 8-1 is made ON, a signal is issued to obtain the refrigerating operation and the cool storage operation, which are alternately executed.

The set switch 8-2 can set a temperature inside the refrigerating compartment to a desired temperature of, for example, -18°C.

The defrost switch 8-3 initiates a defrosting operation, where the refrigerant flow direction switching valve 17 is made ON for a predetermined duration of time, such as one hour, thereby defrosting the refrigerating evaporator 15.

The inner temperature sensor 37 is constructed as a thermistor or thermostat and is arranged at a suitable location inside the refrigerating compartment 3 to detect the inside temperature. The control panel 8 is programmed such that, when the temperature Ta inside the refrigerating compartment 3, as detected by the sensor 37, is reduced to a value which is lower than a first predetermined value T1, which corresponds to the set temperature Ts minus a predetermined temperature reduction ΔT (°C) and is, for example, a value of -20°C, the inside fan motor 32 is made OFF, which allows a cool storage operation to be commenced. When the temperature Ta inside the refrigerating compartment 3 as detected by the sensor 37, is increased to a second predetermined value T2, which corresponds to the set temperature Ts plus a predetermined temperature increase ΔT (°C) and is of, for example, a value of -16°C, the inside fan motor 32 is made ON, which allows a refrigerating operation to be commenced.

The cool storage material temperature sensor 38 is constructed, for example, as a thermistor or thermostat, and is arranged on a surface of the cool storage pack 5 such that the temperature Tb of the cool storage material is detected by the sensor 38. The control panel 8 is programmed such that, when the temperature Tb of the cool storage material detected by the sensor 38 is reduced to a temperature lower than a setting temperature Tg of the cool storage material, i.e., when temperature Tb is reduced to the setting temperature Tg minus a predetermined value ΔT (°C) (for example 25°C - 2°C), the clutch 18 of the refrigerant compressor 11, the inside fan motor 32 and the outside fan motor 34 are made OFF, thereby executing the cool keeping operation.

As explained above, the relay coils 39 to 42 selectively make on or off the relay switches 43 to 46 for selectively energizing the clutch 18 of the refrigerant compressor 11, the inside fan motor 32 and the outside fan motor 34, respectively. In place of such a relay circuit, a semi-conductor switching circuit using semi-conductors can be employed.

As mentioned above, the refrigerating system can take various modes of operation, including the cooling mode, the cool storage mode, the de-frosting mode, and the OFF mode (cool keeping mode) as selected by the control panel 8. The following Table 1 shows, at these various modes, operating conditions of the refrigerant switching valve 17, the electromagnetic clutch 18, the inside fan motor 32 and the outside fan motor 34.

Table 1

Modes	Switching Valve 17	Clutch 18	Inner Fan Motor 32	Outer fan Motor 34
Refrigeration	OFF (Close)	ON	ON	ON
Cool Storage	OFF (Close)	ON	OFF	ON
Defrost	ON (Open)	ON	OFF	OFF
Cool keeping	OFF (Close)	OFF	OFF	OFF

Now, an operation of a control panel 8 of this embodiment will be explained with reference to Figs. 1 to 5. Fig. 5 is a flowchart illustrating a operation of the control panel 8 for switching between the refrigerating operation and the cool storage operation.

When the operation switch 8-1 is made ON, the program begins execution. At step S1, a solidifying temperature Tg of the cool storage material minus a predetermined reduced value ΔT (°C) is calculated. At a following step S2, a set temperature Ts set by the inside temperature set switch 8-2 is read out. At step S3, the first predetermined value T1 = Ts (set temperature) - ΔT is calculated, and the second predetermined value T2 = Ts + ΔT is calculated. At step S4, the inner chamber temperature Ta detected by the inner temperature sensor 37 and the cool storage material temperature Tb detected by the sensor 38 are read out.

At step S5, it is determined if the inside temperature Ta detected by the inside temperature sensor 37 is lower than the first predetermined temperature T1 of, for example, -20°C. When a result of the determination at the step S5 is "No", i.e., the inside temperature Ta is higher than the first predetermined temperature T1, the routine goes to step S6, where it is determined if the inside temperature Ta detected by the inside temperature sensor 37 is higher than the second predetermined temperature T2 of, for example, -16°C. When a result of the determination at the step S6 is "Yes", i.e., the inside temperature Ta is higher than the second predetermined temperature T2, the routine goes to step S7, where the refrigerating operation is executed by making ON the clutch 18 of the refrigerant compressor 11, and the inside and outside fan motors 32 and 34 and by making OFF the refrigerant flow switching valve 17. The routine goes to step S2 for a repetition.

When a result of a determination is "Yes" at the step S5, i.e., the inside temperature Ta is lower than the first predetermined temperature T1 (Ta ≦ -20°C), or a result of a determination is "No" at the step S6, i.e., the inside temperature Ta is lower than the second predetermined temperature T2 and higher than the first predetermined value (-20°C < Ta < -16°C), the routine goes to step S8, where it is determined if the temperature of the cool storage material Tb detected by the sensor 38 is lower that the setting temperature Tg (-25°C) minus ΔT (-2°C). When a result of "No" is obtained at the step S8 (Tb > -27°C), the routine goes to step S9, where the cool storage operation executed by making ON the clutch 18 of the refrigerant compressor 11 and the outside fan motor 34 and by making OFF the refrigerant flow switching valve 17 and the inside fan motor 32. The routine goes to step S2 for a repetition.

When a result of a determination is "Yes" at the step S8 (Tb ≦ -27°C), the routine goes to step S10, where the cool keeping operation executed by making OFF the clutch 18 of the refrigerant compressor 11, the inside and outside fan motors 32 and 34, and the refrigerant flow switching valve 17. It should be noted that the "No" determination at step S6 (-20°C < Ta < -16°C) can cause the routine goes to step S9 without executing the step S8.

Now, an operation of the refrigerating system 1 for a refrigerated vehicle will be explained with reference to Figs. 1 to 4 and 6A to 6E. Figs. 6A to 6E illustrate timing charts illustrating an inside temperature, an evaporating temperature, an operating condition of the inside fan, an operating mode of the apparatus and an operating condition of the electromagnetic clutch, respectively. At time t0, the operating switch is made ON, which causes the compressor 11, the inside fan 31 and the outside fan 33 to be brought into operation. The refrigerant flow direction switching valve 17 is maintained in its OFF condition, so that a flow of the refrigerant by way of the first refrigerating passageway 29 is obtained. As a result, the gaseous state refrigerant of a high temperature and pressure from the compressor 11 is introduced into the condenser 12, where the refrigerant is liquidized, and into the receiver 12a where separation occurs between the gaseous and liquid phases. Only the liquid state refrigerant is introduced into temperature operated automatic valve 13, where the liquid state refrigerant is subjected to a rapid expansion, so that the refrigerant is changed to a mist state (gas and liquid combined state) at a low temperature and pressure. The mist state refrigerant is introduced into the circular tube 25 of the cool storage evaporator 14, so that a heat exchange occurs between the refrigerant and the cool storage material in the cool storage packs 5, so that the refrigerant is evaporated, so as to obtain a gas and liquid combined state, where the amount of the gaseous component is larger than the amount of the liquid component. The combined state refrigerant is introduced into the refrigerating evaporator 15. The heat exchange of the refrigerant with the cool storage material causes the temperature of the cool storage material in the cool packs 5 to be reduced due to the evaporation heat of the refrigerant at the cool storage evaporator 14. The gas and liquid combined states of refrigerant is, then, introduced into the refrigerating evaporator 15, so that a heat exchange with the refrigerant occurs with respect to the inside air flow generated by the inside fan 31, so that the refrigerant is evaporated and is introduced into the accumulator 16. At the accumulator 16, the gaseous state refrigerant is separated from the liquid state refrigerant and is introduced into the compressor 11, thereby repeating the refrigerating cycle.

During the execution of the refrigerating cycle, the air, cooled at the refrigerating evaporator 15 by means of the evaporating heat of the refrigerant, is discharged from the duct 28-1 of the cooling device into the space inside the refrigerating compartment 3. As a result of a continuation of such a cooling operation of the refrigerating compartment, the evaporating temperature of the refrigerant at the cool storage evaporator 14 as well as the refrigerating evaporator 15 is reduced as shown in a line m in Fig. 6B. As a result, the temperature inside the refrigerating compartment 3 is also reduced as shown by a line n in Fig. 6A.

When the inside temperature Ta is reduced to the first predetermined temperature T1 (-20°C) at a timing t1, the control panel 8 causes the inside fan motor 32 to be made OFF, which prevents the inside fan 31 to be rotated, while maintaining the outside fan 33 as well as the elector-magnetic clutch 18 to be operated, so that the refrigerating cycle is continued, thereby executing the cool storage operation. In this cool storage operation, an air flow contacting with the refrigerating evaporator 15 is stopped, thereby reducing the heat exchange capacity at the evaporator 15. In other words, the refrigerating evaporator 15 does not substantially act to evaporate the refrigerant. As a result, the temperature of the gaseous refrigerant at the refrigerating evaporator 15 is reduced. Thus the pressure at the temperature sensitive tube 23 opened to the diaphragm actuator 24-1 via the conduit 24 causes the degree of the throttle of the valve member 21 of the expansion valve 21 to be reduced, thereby reducing the amount of the refrigerant introduced into the cool storage evaporator 14.

It should be noted that the evaporating temperature of the refrigerant recirculating in the refrigerating circuit 4, i.e., the temperature of the refrigerant evaporated at the cool storage evaporator 14 is determined when a capacity Qa at the air side and a capacity QR at the refrigerant side are balanced, which are expressed by the following equations, that are

$$Qa = W \times \phi \times \Delta T,$$

where W is a predetermined value in Kcal/(h°C) determined by the amount of air flow generated by the inside fan 31,

ϕ is a value determined in accordance with shapes of the cool storage evaporator 14 and the refrigerating evaporator 15 such as a heat transfer area or heat transfer coefficient, and

$$QR = Gr \times \Delta i,$$

where QR is an amount in Kg/h of the refrigerant recirculated in the refrigerating unit 4, and

Δi is a difference in enthalpy in kcal/kg between the inlet side of the cool storage refrigerant 14 and the outlet of the refrigerating evaporator 15.

As a result, the evaporating temperature of the refrigerant at the cool storage evaporator 14 is, from the first evaporating temperature Te1 (-25°C) at the timing t1 when the inside fan motor 32 is made off, further reduced to a second evaporating temperature Te2 (-35°C), as shown by a curve o in Fig. 6B. As a result, in the cool storage evaporator 14, the cool storage material in the cool storage packs 5 covering the circular tube 25 is further cooled, thereby executing cool storage operation. During the execution of the cool storage operation, the inside temperature is increased as shown by a curve p in Fig. 6A.

At a timing t2, the inside temperature Ta in the refrigerating compartment 3 is increased to the second predetermined value T2 (-16°C), the inside fan motor 32 is again made ON, so that the inside fan 31 generates a flow of the air inside the refrigerating compartment 3 induced by the convection thereby commencing the refrigerating operation.

The repetition between the refrigerating operation and the cool storage operation, taken place alternately, causes the temperature Tb of the cool storage material in the cool storage packs to be lower than the setting temperature Tg (-25°C) minus a predetermined value ΔT (-2°C), by which it is judged that the freezing of the cool storage material is completed. In this case, a refrigerating operation by making ON the electro-magnetic clutch 18 and a rest (cool keeping) operation by making OFF the clutch 18 are repeated for controlling the temperature of the refrigerating compartment. Namely, the refrigerating operation is continued to a time t_4, where the temperature of the refrigerant is reduced to a first temperature T_1 Then the clutch 18 and the fan motor 32 are made OFF, so as to commence the cool keeping operation. Namely, the latent heat of the cool storage material in the packs 4, when it is molten, can prevent the inside temperature form being quickly increased.

A stoppage of the operation of the internal combustion engine 20 causes the refrigerating unit 4 to be de-energized, which causes the inside temperature of the refrigerating compartment 3 to be increase, thereby the cool storage material to be molten. The melting latent heat of the cool storage material in the cool storage packs 5 causes the cool keeping operation of the refrigerating compartment to be executed.

By the control panel 8, the refrigerant flow switching valve 17 is made ON, when the defroster switch is made ON by an operator or, during the refrigerating or the cool storage operation of the refrigerating operation, a predetermined condition is detected such that a predetermined value of the evaporating pressure or the temperature of the refrigerating evaporator 15 is detected or a predetermined duration of, for example, 1 hour of the refrigerating or cool storage operation is obtained. Such a switching on of the valve 17 causes the flow of the refrigerant to be switched from the first refrigerating passageway 29 to the second refrigerant flow passageway 30 as shown by the arrow b in Fig. 1. As a result, the defrosting operation is commenced. Namely, the refrigerant of a high temperature or high pressure is directly introduced into the refrigerant evaporator 15 via the second refrigerating passageway 30. As a result, the surface of the refrigerant evaporator 15 is defrosted or de-iced.

As explained above, in the first embodiment, the cool storage evaporator 14 and the refrigerating evaporator 15 are connected in series, and the temperature sensitive expansion valve 13 is for controlling the degree of the throttle in accordance with the change in the temperature at the cutlet of the refrigerating evaporator 15. Furthermore, the melting temperature of the cool storage material in the cool storage packs 5 of the cool storage evaporator 14 is determined so that it is the same degree as the evaporating temperature, for example -25°C, of the refrigerant in the refrigerating evaporator 15 when the temperature inside the refrigerating compartment 3 is reached to the first predetermined value. A cooling of the cool storage material having such a value of the melting temperature by the cool storage evaporator 14 prevents the cool storage material in the cool storage evaporator 14 from being frozen, thereby preventing the cool storage material from being over-loaded. Furthermore, in the cool storage operation, the throttling operation of the temperature sensitive expansion valve 13 can maintain a suitable difference between the temperature of the cool storage material and the evaporating temperature of the refrigerant in the cool storage evaporator 14. As a result, in the refrigerating system for the refrigerated vehicle, the refrigerating operation and the cool storage operation, which take place alternately, can be executed efficiently.

Furthermore, in the first embodiment, downstream from the cool storage evaporator 14, the refrigerating evaporator 15 is connected in series, and the second refrigerant passageway 30 connects the outlet 11-1 of the compressor 11 directly with the inlet of the refrigerating evaporator 15. As a result, during the defrost operation of the refrigerating unit 4 i.e., when the refrigerating evaporator 15 is defrosted, the gaseous refrigerant of a high temperature and pressure from the outlet of the compressor 11 is introduced into the refrigerating evaporator 15 while by-passing the condenser 12, the expansion valve 13 and the cool storage evaporator. As a result, the cool storage material in the cool storage packs 5 of the cool storage evaporator 14 is prevented from being melted.

In short, in the refrigerating system 1 in the first embodiment of the present invention as explained above, only one refrigerant flow direction switching valve 17 is sufficient for obtaining an effective refrigerating operation with a cool storage function, thereby reducing the number of parts as well as the production cost.

Fig. 7 shows a second embodiment of the cool storage evaporator 14 of the refrigerating system for a refrigerated vehicle. The cool storage evaporator 14 includes a container 52 and a serpentine arrangement of the refrigerant pipe 53. The container 52 stores the cool storage material 51 with which the refrigerant pipe 53 is contacted. This construction is advantageous in that the weight of the device is reduced. Furthermore, the refrigerant pipe 53 is, on its outer surface, formed with fins 54 of a spiral fin structure or plate fin structure for increasing a heat exchanging capacity. The refrigerating pipe 53 has a first end 55 for receiving the refrigerant from the expansion valve 13 and a second end 56 for discharging the refrigerant into the refrigerating evaporator 15.

In a third embodiment shown in Fig. 8, the cool storage evaporator of a refrigerating system for a refrigerated vehicle includes a container 52 similar to as that in the second embodiment in Fig. 7, in which container 52 capsules 57 made of resin or metal material for sealingly storing therein the cool storage material are filled.

A fourth embodiment will now be explained. Fig. 9 shows a construction of the temperature sensitive expansion valve 13 in this embodiment. Namely, as in to the first embodiment, the temperature operated automatic expansion valve 13 includes a valve casing 21, a temperature sensitive unit 22, which is constructed by a thermo-sensitive tube 23 and a capillary tube 24, a valve rod 71, a first and second ball shaped valves 61 and 62 fixed on the valve rod 71 and arranged movably in the valve casing 21 so as to create variable throttles 65 and 66, respectively, a diaphragm mechanism 67 for generating a pressure force in the valve rod 71, a coil spring 63 for urging the valve rod 71 toward the diaphragm mechanism 67, a spring seat 73, which receives at its first end the second ball shaped valve 62 and is connected at its second end to the upper end of the spring, and an adjusting screw 74 to which the lower end of the spring 63 rests.

The valve casing 21 is formed from a metal material such as brass and is formed therein with a passageway 64 of a generally L-shape and for a refrigerant. The L-shaped passageway 64 has an upstream end connected to an outlet to the condenser 12 for receiving the liquid state refrigerant as shown by an arrow r and a downstream end connected an inlet of the cool storage evaporator 14 for discharging the refrigerant thereto as shown by an arrow s. In Fig. 9, the first and second orifices 65 and 66 are located in series in the refrigerant passageway 64. The first orifice 65 on the upstream side has an inner diameter which is larger than that of the second orifice 66 on the downstream side. Furthermore, the inner diameters of the first and second orifices 65 and 66 are such that the first and second balls 61 and 62 are freely movable in the orifices 65 and 66, respectively, without contacting with the inner walls of the orifices 65 and 66, respectively.

The diaphragm actuator 67 is constructed by a lower diaphragm cover 67-1 connected to a valve casing 21, an upper diaphragm cover 67-2 connected to the lower diaphragm cover 67-1, a diaphragm 70 between the upper and lower diaphragm covers 67-1 and 67-2, and a diaphragm stopper 72 concentrically connected to the rod 71. An upper diaphragm chamber 68 is formed on an upper side of the diaphragm 70, while a lower diaphragm chamber 69 is formed on a lower side of the diaphragm 70. The upper diaphragm chamber 68 is connected to the capillary tube 24. The casing 21 is formed with an opening 21a having a first end opened to the lower chamber 69 and a second end connected to a pressure equalization conduit 60, which is connected to a refrigerating pipe in Fig. 1 at a location between the temperature operated automatic valve 13 and the cool storage evaporator 14, so that the pressure in the lower chamber 69 corresponds to a lower pressure, i.e., an evaporating pressure in the refrigerating recirculation system.

Inside the temperature sensitive tube 23, an amount of a gaseous refrigerant, which is the same refrigerant as that recirculated in the refrigerating system, is sealingly stored. Furthermore, as explained with reference to Fig. 1, the temperature sensitive tube 23 is arranged to be in side by side contact with the refrigerant tube at the outlet of the refrigerant evaporator 15. As a result, a pressure inside the temperature sensitive tube 23, i.e., the pressure in the upper chamber 68 is varied in accordance with the temperature of the refrigerant flowing in the refrigerating recirculation system.

In view of the above, a pressure corresponding to the pressure at the thermo-sensitive tube is generated in the upper chamber 68, which causes the diaphragm 70 to be moved downwardly. Furthermore, a pressure corresponding to the lower pressure in the refrigerating system is generated at the lower diaphragm chamber 69, which causes the diaphragm 70 to be moved upwardly. Furthermore, the spring 63 generates a force for moving the diaphragm 70 upwardly. As a result, the ball shaped valves 61 and 62 on the shaft 71 connected to the diaphragm 70 are located at respective positions, which are determined by a balance between the downwardly directed force by the pressure at the upper chamber 68 and the upwardly directed forces by the pressure at the lower chamber 69 and by the spring 63, and which determine the degrees of the throttle at the orifices 65 and 66, respectively. A screw adjustment of the screw 74 causes the latter to be moved axially, thereby varying the spring force of the spring 63, i.e., the pressure for making the second ball valve 62 open.

Now, an operation of the fourth embodiment in Figs. 9 to 11 will be explained. A refrigerating operation for reducing the inside temperature of the refrigerating compartment causes the refrigerating load to be increased, thereby increasing the temperature of the gaseous refrigerant at the outlet of the refrigerant evaporator 15. As a result, the gaseous refrigerant in the temperature sensitive tube 23 is subjected to expansion, so that the pressure at the upper diaphragm chamber 68 is higher than the pressure at the lower diaphragm chamber 69, which causes the operating rod 71 to be moved downwardly. As a result, the first ball valve 61 takes a first position as shown in Fig. 1, where the first ball valve 61 is downwardly spaced from the first orifice 65. In this first position, the degree of the throttle of the first orifice is small, which prevents the refrigerant passing through the orifice 65 from being subjected to an adiabatic expansion. As a result, the liquid state refrigerant introduced into the refrigerant passageway 64 as shown by the arrow r from the condenser is passed through the first orifice 65 as shown by an arrow t without being subjected to the adiabatic expansion, and is introduced into the second orifice 66 in the liquid state. In this case, the second ball shaped valve 62 is, as shown in Fig. 9, at a position, where the second valve 62 is spaced from the second orifice 66, so that a small degree of the throttle of the second orifice 66 is obtained, thereby obtaining a large amount of the recirculate amount of the refrigerant passing through the second orifice 66 as shown by an arrow u. The refrigerant is, when passing through the second orifice 66 as shown by the arrow u, subjected to the adiabatic expansion due to the small inner diameter of the orifice 66. The adiabatic expansion occurred when the refrigerant passes through the second orifice 66 as shown by the arrow u causes the refrigerant to be expanded, thereby obtaining a gas/liquid combined state refrigerant at a low temperature and pressure. Such a gas/liquid combined state refrigerant issues from the expansion valve assembly 13 as shown by the arrow s in Fig. 9, and is introduced into the tube 25 (Fig. 3) of the rounded cross-sectional shape of the cool storage packs 5. As a result, a heat exchange is occurred between the refrigerant and the cool storage material in the packs 5, so that the refrigerant is evaporated and so that the gas/liquid combined state refrigerant of an increased amount of gaseous state is obtained and is introduced into the refrigerant evaporator 15. The evaporating heat of the refrigerant at the cool storage evaporator 14 causes the cool storage material in the cool storage packs 5 to be subjected to temperature reduction. On the other hand, the mist state refrigerant flowing into the refrigerant evaporator 15 is subjected to heat exchange with the inside air flow generated by the inside fan 31 as rotated by the electric motor 32, so that the refrigerant is evaporated under a super heated condition at the outlet of the refrigerant evaporator 15. Finally, the degree of opening of the second orifice 66 is such that a large amount of the refrigerant passing through the orifice 66 suitable for the high load operation is obtained, which allows the inside air in the refrigerating compartment 3 to be effectively cooled, thereby reducing the inside temperature of the refrigerating compartment.

A cool storage operation is obtained by making OFF the inside fan motor 32, while maintaining the ON conditions of the electromagnetic clutch 18 as well as the outside fan motor 34. The stoppage of the inside fan 31 in this cool storage operation causes the heat exchange to be reduced between the refrigerant in the refrigerant evaporator 15 and the inside air in the refrigerating compartment, thereby substantially preventing the refrigerant from being evaporated. The reduction of the refrigerating load in the refrigerating compartment 3 causes the temperature of the refrigerant to be reduced at the outlet of the refrigerant evaporator 15, which causes the gas in the temperature sensitive tube to be compacted. As a result, the pressure at the upper diaphragm chamber 68 is reduced toward the pressure at the lower diaphragm chamber 69, so that the diaphragm 70, i.e., the operating rod 71 is moved upwardly to a position as shown in Fig. 10. In this case, the first ball shaped valve 61 is located to be vertically aligned with the first orifice 65, while the second ball shaped ball valve 62 is located vertically aligned with the second orifice 66. The throttling operation by means of the second ball shaped valve 62 causes the evaporating pressure to be reduced in the refrigerant recirculating system, on one hand, and the recirculated amount of the refrigerant to be reduced, on the other hand. As a result, the refrigerant passed through the first orifice 65 is subjected to an adiabatic expansion, thereby causing the refrigerant to be in a gas/liquid combined state. In other words, the state of the refrigerant introduced into the second orifice 66 is under the gas/liquid combined state rather than the liquid state. Due to the combined state of the refrigerant at the second orifice 66, the flow area is increased while maintaining the same amount of the recirculated refrigerant. Thus, the second ball valve 62 can be operated in a range for controlling the degree of the superheating of the refrigerant.

In Fig. 11, the temperature operated expansion valve of a conventional structure employed in the first embodiment in Fig. 1 has a structure as shown in a block b, where only a signal orifice a is provided. Contrary to this, the evaporating temperature is different between the cool storage evaporator 14 and the refrigerant evaporator 15. In this case, the volume as well as the opening pressure of the conventional temperature sensitive valve can be set for the higher evaporating temperature at the refrigerant evaporator 15. In this case, switching to the cool storage operation due to a reduced load causes the temperature sensitive valve to throttle the orifice, so as to make the system to respond to a small necessary amount of the recirculated refrigerant. However, such a reduction of the recirculated refrigerant occurs very rapidly as shown by a dotted curve x in Fig. 11, thereby causing the valve to be out of a control range, thereby generating hunting as large as H_1 for a fixed valve lift y. Contrary to this, a setting of the volume as well as the opening pressure of the conventional temperature sensitive valve suitable for the lower evaporating temperature at the cool storage evaporator 14 causes the recirculating amount of the refrigerant to be reduced, which causes the cooling capacity of the system to be reduced. In short, a single orifice structure b is disadvantageous in that a requirement for stable control during a low load condition (cool storage operation) and a desired cooling capacity during a high load condition can not be harmonized.

In the fourth embodiment of the present invention, the first and second orifices 65 and 66 controlled by the ball shaped valves 61 and 62, respectively, are provided. Such a construction of the fourth embodiment can harmonize the above mentioned contradictory requirements. Namely, during the refrigerating operation wherein the lift of the valve is large, the second orifice 62 functions to vaporize the refrigerant, which is effective for preventing the cooling down capacity from being reduced. During the cool storage operation where the lift of the valve is small, the first orifice 65 functions to vaporize the refrigerant, downstream of which the second orifice 66 as well as the second valve 62 are located as shown by a block 13 in Fig. 11. Since the refrigerant at the second orifice 66 is under a liquid/gas combined state unlike the liquid state at the second orifice during the high load mode, the second ball valve 62 can obtain a gradual reduction of the recirculated amount with respect to a change in the degree of the throttle as shown by x' in the solid curve in Fig. 11. In other words, the second valve 66 is moved in a range wherein a degree of superheat of the refrigerant is controlled, thereby reducing the amount of hunting to as small as H_2 for the same fixed valve lift y.

Now, a fifth embodiment of the present invention will be explained with reference to Figs. 12 and 13. In Fig. 12, showing a refrigerant recirculating system, wherein a temperature operated automatic expansion valve 13, of a usual type including, therein, a second throttle portion, and an electromagnetic valve 76 are arranged on the refrigerant tube at a location between the outlet of the condenser 12 and the inlet of the temperature operated expansion valve 13. As shown in Fig. 13, the electromagnetic valve 76 includes a housing 78 having refrigerant passageways 77 and 77-1, a valve opening 79 between the passageways 77 and 77-1 and by-pass port 75 by-passing the valve port 79, the electromagnetic valve 76 further includes a needle valve 80 for selectively opening or closing the valve port 79, a valve seat 84 and a electromagnetic actuator 81 for operating the needle valve 80. The electromagnetic actuator 81 is constructed by a plunger 81-1 connected to the needle valve 80, a spring 83 for generating a spring force for causing the needle valve 80 to be seated on the valve seat 84 and a electromagnetic coil 82 for generating an electromagnetic force for causing the plunger 81-1 to be moved against the force of the spring 83.

In this fifth embodiment, the electromagnetic coil 82 is, under the low load condition such as a cool storage operation, de-energized, so that the needle valve 80 shuts off the valve port 79. As a result, the flow of the refrigerant from the condenser 12 to the expansion valve 13 is occurred by way of the by-pass port 75. The refrigerant passing through the by-pass port 75 of a reduced dimension is subjected to an adiabatic expansion so that a gas/liquid combined state of the refrigerant is obtained. Contrary to this, during a high load operation including a refrigerating operation, the electromagnetic coil 82 is energized, so that the plunger 81-1 connected to the needle valve 80 is moved upwardly against the spring force of the spring 83. As a result, the refrigerant passes the valve port 79 of an increased dimension while maintaining the liquid state, thereby increasing a recirculated amount of the refrigerant. Namely, the fifth embodiment operates in the same way as the fourth embodiment in that recirculated amount of the refrigerant is controlled in accordance with the refrigerating load.

Now, a temperature operated expansion valve in sixth embodiment will be explained with reference to Figs. 14 and 15. In Fig. 14, the temperature operated expansion valve 13 includes a disk 85 as a first valve and a ball 62 as a second valve. A first seat plate 87 includes a central opening 88 through which the valve shaft 71 passes, and a plurality of circumferentially spaced orifices 65. Another seat plate 86 is located downstream from the first plate 87 and is formed with an orifice 66. A valve 85 of a disk shape faced with the opening 88 is fixedly connected to the shaft 71. A valve 62 of a ball shape faced with the orifice 66 is fixedly connected to the valve shaft 71. The central communication opening 88 has an effective opening area larger than that of the second orifice 66. Furthermore, the first orifice 65 in the plate 87 has an effective area which is smaller than the effective area of the second orifice 66. AS a result, when the refrigerant passes through the first orifice 65, an adiabatic expansion occurs in the refrigerant.

During the operation of the temperature operated expansion valve of the sixth embodiment as explained above, a low load operation caused by the cool storage operation causes the diaphragm 70 to be moved upwardly to take a position as shown in Fig. 14, where the plate shaped valve closes the central opening 88, so that the refrigerant from the condenser introduced into the passageway 64 is passed through the first orifices 65, whereat the refrigerant is subjected to adiabatic expansion, thereby obtaining a gas/liquid combined state refrigerant, which is introduced into the second orifice 66. Thus, in this low load condition, the second valve 62 of the ball shape controls the flow of the gas/liquid combined state refrigerant from the first orifice 65. Contrary to this, a high load operation caused by the refrigerating operation causes the diaphragm 70 to be moved downwardly to take a position as shown in Fig. 15, where the plate shaped valve 85 is displaced from the seat plate 87, thereby opening the central opening 88, so that an increased amount of the refrigerant from the condenser 12 introduced into the passageway 64 is passed through the central opening 88 of an increased dimension while maintaining a liquid state condition. Namely, a similar operation as that in the fourth embodiment in Figs. 9 to 11 is obtained.

As seventh embodiment will now be explained with reference to Figs. 16 to 18. Fig. 16 shows a refrigerated vehicle provided with a refrigerating system includinq a cool storage evaporator 14. The cool storage evaporator 14 is arranged on an upper part of the refrigerating compartment 3, and is constructed by cool storage packs 5 formed as containers for storing a cool storage material made of a resin of an increased heat conductivity and by a serpentine tube 90 of a circular cross sectional shape of an outer diameter of 15.8 mm. The serpentine tube 90 extends in a vertical plane and is constructed by straight pipe portions and U-shaped connecting portions, which are arranged alternately. Opposite pairs of the cool storage packs 5 are provided, between which the straight portions of the serpentine tube 90 are sandwiched, so that the straight and U-shaped portions are partly downwardly projected out of the cool storage packs 5. The straight portions and the U-shaped portions, which are not sandwiched by the cool storage packs 5, construct a heat absorber 91 (lower section), while the straight portions, which are sandwiched by the cool storage packs, construct a heat emitter section 92 (upper section). A value of length L of the heat absorbing section 91 from the bottom end of the cool storage packs 5 is in a range between 0.6m to 0.7m. The circular cross sectional tube 90 has an inlet 93 for the introduction of the refrigerant and an outlet 94 for the discharge of the refrigerant. The heat absorber 91 of the rounded tube 90 may be the type with fins so as to increase a heat exchanging capacity. Finally, the heat absorber 91 of the rounded tube may be the one with spine fins so as to increase a heat conduction area, thereby improving a cool keeping capacity.

Now, an operation of the seventh embodiment will be explained with reference to Figs. 16 to 18. A cool keeping operation is executed, when it is required that a low temperature is maintained inside the refrigerating compartment 3, while the engine is stopped. Such a cool keeping operation is desirable when an emission of an exhaust gas from the engine is not allowed or a reduction of a noise is required. Fig. 17 illustrates a condition of the refrigerant in the rounded tube under the a cool keeping operation. Namely, at the heat absorber 91 located outside the cool storage packs 5, heat from a low temperature inside air at, for example, -10°C is absorbed by the liquid state refrigerant in the bottom of the tube 90, thereby gasifying the refrigerant. The gasified refrigerant is moved upwardly toward the heat emitter 92 as shown by arrows w. At the heat emitter 92, the tube 90 is sandwiched by the cool storage packs 5, in which the cool storage material is under a refrigerating condition of, for example, temperature of -25°C. As a result, at the heat emitter

92, the cool storage material is condensed and liquidized, so that a heat is emitted to the cool storage packs 5, thereby obtaining a so-called heat pipe effect.

In a situation where an emission of an exhaust gas or an operating noise is strongly restricted, it is necessary for a refrigerated vehicle to be provided with means for keeping a low temperature inside the refrigerating compartment under a stopped condition of an internal combustion engine of the refrigerated vehicle. In view of this requirement, a technic has been proposed, where a cool storage material sealingly stored in a metal container is frozen at night by using an outside electric power source. During transportation by a refrigerated vehicle, latent heat generated when the cool storage material is melted is used for keeping a low temperature inside the refrigerating compartment without operating the refrigerating system. However, this prior art is disadvantageous due to an increased weight and manufacturing cost due to the use of the metal container. Thus, a proposal is made wherein the container is made of a plastic material. However, such a container made of a plastic material is disadvantageous due to a large thermal resistance, thereby reducing a cool keeping capacity when compared with the metal container. Contrary to this, in the above mentioned seventh embodiment, the rounded tube 90 of the heat accumulating evaporator 14 is constructed so as to function as a heat pipe. Due to the employment of the heat pipe construction, an increase in the heat absorbing capacity is obtained, thereby providing a desired cool keeping operation, even if the container for constructing the cool storage packs 5 is made of plastic material. In the seventh embodiment as illustrated above, the rounded tube 90 is arranged so that its extends vertically along the length thereof in order to construct the heat absorber as constructed to be function as a heat pipe. However, a refrigerant pipe extending horizontally can obtain a similar heat pipe function for executing the cool keeping operation so long as the heat emitter of the cool storage packs 5 is not inclined downwardly with respect to a horizontal direction.

Now, result of a test by the inventor will be explained with respect to the construction of the seventh embodiment. The test was done when the outside air temperature was 35°C with regard to the refrigerating compartment of a length of 2960 mm, of width of 1600 mm, of a height of 1690 mm and of a wall thickness of 75 mm. Furthermore, for cool storage evaporator of a refrigerating system for a refrigerated vehicle, in addition to the construction in the seventh embodiment of the rounded tube 90 with the heat pipe function, a construction of a prior art with a refrigerant pipe with the heat pipe function were prepared. For both of the apparatus in the present invention and in the prior art, the temperature inside the refrigerating compartment after the freezing of the cool storage material was detected. The results are shown in Fig. 18. Namely, a solid curve shows a change in a temperature inside the refrigerating compartment after the completion of the freeze for the construction of the seventh embodiment, while a dotted curve shows a result for a conventional structure. As will be clearly seen from the result of the test in Fig. 18, the present invention can maintain an inside temperature lower than -5°C even after lapse of 60 minutes. Contrary to this, in the conventional structure, the inside temperature is higher than -5°C when 60 minutes has lapsed from the completion of the freeze. In short, an improvement in the cool keeping capacity is obtained by the structure of the present invention.

Fig. 19 shows a cool storage evaporator 14, in the eighth embodiment, which is arranged on a side wall the refrigerating compartment on a refrigerated vehicle. Namely, the cool storage evaporator 14 includes six cool storage packs 5 each including a container made of a plastic material of an increased heat conductivity for storing therein a cool storage material, and a rounded tube 35 including vertically spaced straight portions 95 extending horizontally and looped portions 95-1 connecting the straight portions 95 with each other. In place of the construction of the rounded tube 35 in Fig. 19, a construction of the rounded tube 90 in Fig. 16 can be employed in order to improve the heat conducting capacity as well as the refrigerating capacity.

In Fig. 19, the six cool storage packs 5 are arranged to surround the four straight portions of the rounded tube 95. Namely, each pack 5 is constructed by a first and a second members 5-1 and 5-2, which are faced with each other by way of the straight portions of the rounded tube 95, thereby obtaining the structure. Furthermore, in the vertical direction, two packs are arranged, while, in the horizontal direction, three packs are arranged. In Fig. 19, only one pack is shown, and remaining five packs are not shown for the sake of the simplicity. Furthermore, an attachment device 200 is provided for fixedly connecting the cool storage evaporator 14 to an inner side wall of the refrigerating compartment 3. The attachment device 200 includes two vertically extending ended fixing members 201, two vertically extending intermediate fixing members 202, six vertically extending rear side fixing members 203, three vertically extending front side fixing members 204 and fixing members 205 such as screws or bolts for connecting the fixing members 201, 202, 203 and 204 with each other and for connecting the members to the side wall of the refrigerating compartment 3.

Each of the end fixing members 201 is made from a metal plate of a substantially C-cross sectional shape and is formed with vertically spaced openings, to which the straight portions of the tube 5 are inserted, respectively, so that the U-shaped portions 95-1 are projected out of the member 201. Furthermore, the end fixing member 201 is further formed with holes 211 and 212 for allowing the screws or bolts to be passed therethrough. As shown in Fig. 9, the rounded hole 211 has an inner diameter larger than that of the rounded hole 212.

The intermediate fixing members 202 are arranged between the end fixing members 201 and each is formed as a metal plate of a substantially Z-cross sectional shape. Furthermore, the intermediate fixing member 202 forms vertically spaced holes, through which the straight portions of the tube 5 are inserted. Finally, the intermediate fixing member 202 forms rounded holes 213, through which the screws or bolts 205 are inserted.

The rear side fixing members 203 are arranged between the cool storage evaporator 14 and the side wall of the refrigerating compartment 3 and are, each, constructed by a metal plate of a cross-sectional shape as shown in Fig. 19. In detail, three vertical pairs of fixing members 203, which are arranged symmetric and contacted along their faced vertical edges, are provided. These vertical pairs are arranged between the plates 201 and 213, between the plates 213 and between the plates 213 and 212, respectively. Finally, the rear side fixing member 203 forms rounded holes 214 and 215 for receiving the screws or bolts 205.

The front side fixing members 204 are arranged so as to be extended vertically and are arranged between the plates 201 and 213, between the plates 213 and between the plates 213 and 212, respectively, so that the front side fixing members 204 face corresponding pairs of the rear side fixing members 203. Furthermore, between front side fixing member 204 and the pair of the rear side fixing members 203, two vertically spaced cool storage packs 5 are arranged, each pack includes the first and second members 5-1 between which the four straight pipe portions are arranged. Finally, the front side fixing member 204 forms rounded holes 216 and 217 for the passage of the screws 205.

The screw members 205 are, at the final stage of a mounting process, introduced into the holes 216 of the front plates 204 and then into the holes 214 of the rear plates 203 and introduced into the holes 217 of the front plates 204 and then into the holes 215 of the rear plates 203, so that the screw members 205 can be tightened. Due to such a tightening force, the cool storage packs 5 are fixed between the faced front plates 204 and the rear plates 203, while the refrigerating tubes 95 are held by the cool storage packs 5, thereby obtaining the cool storage evaporator assembly. Then, the screw 205 are inserted to the holes 211 and then to the hole 212 of the upright members 201. Furthermore, the screws 205 are inserted to the holes 213 of the upright members 202, so that the cool storage evaporator assembly is connected to the inner side wall of the refrigerating compartment 3.

Figs. 20 and 21 show a cool storage evaporator in a ninth embodiment. The cool storage evaporator 14 in this embodiment is connected to a ceiling 300 of the refrigerating compartment 3. The cool storage evaporator 14 is constructed by a group 301 of packs 5 arranged in a matrix ($3 \times 4 = 12$). Each pack 5 is constructed by a container for storing therein a cool storage material. The container has at its bottom surface grooves 5-3 along the length thereof. The cool storage evaporator 14 is further included with a rounded tube 95 of a serpentine shape for cooling the cool storage material in the packs 5, a resilient plate 302 to be arranged between the packs 5 and the ceiling 300, and a box shaped casing 303 with opened top for storing therein the packs 5, the tube 95 and the resilient plate 312.

The resilient plate 312 is formed generally as a rectangular plate shape constructed by a sponge, an air cushion, rubber or a plate spring. The resilient plate 302 is, as shown in Fig. 20, constructed as a flat plate portion 311 for urging the array of the packs 5 toward the bottom of the casing 303, a pair of side walls 312 extending along the width of the flat plate portion 311 and a pair of side walls 313 extending along the length of the flat plate portion 311. The side walls 312 and 313 extend downwardly so as to be sandwiched between the casing 303 and the packs 5.

The box shaped casing 303 with bottom is made from metal plate of a high heat conductivity by pressing. Namely, the casing 303 is formed with opposite walls 321 extending along the width, opposite walls 322 extending along the length, and a bottom wall 323 of an elongated rectangular shape. The casing 303 is further formed with flanges 324 extending horizontally from the side walls 321 at their top portions. The flanges 324 are formed with rounded holes 324-1 for screws or bolt for connecting the casing the top wall 300 of the refrigerating compartment 3. Finally, the bottom wall 323 of the casing 303 is formed with groove 325 of a arc-shaped cross-sectional shape. Furthermore, the groove 325 extends along the serpentine shape of the tube 95 constructed by the straight portions and the U-shaped portions, so that the tube 95 is, at its lower side, fitted to the groove 325 as shown in Fig. 21. As shown in Fig. 20, the side wall 321 of the casing 303 is formed with a hole 326 for inserting the inlet part of the tube 95 and a hole 327 for inserting the outlet part of the tube 95.

The ninth embodiment in Figs. 20 and 21 is advantageous in that the number of parts are reduced, on one hand, and a work for mounting is reduced, on the other hand. Furthermore, a resilient mounting of the cool storage packs 5 are realized, which is advantageous in preventing the packs from being damaged during the mounting. Namely, in the ninth embodiment, the flanges 324-1 of the casing 303 are directly connected to the inner top wall 300 of the refrigerating compartment 3 without using any additional parts, such as the upright members 201 to 204 in the eighth embodiment. Thus, the cost is reduced in view of the fact that the number of parts is reduced and that the work for the mounting is reduced. Furthermore, in a connected condition of the cool storage evaporator 14 to the ceiling wall 300 of the refrigerating compartment 3 as shown in Fig. 21, the resilient plate 302 exists between the ceiling wall 300 and the cool storage packs 5. Thus, when a cubical expansion of the cool storage material in the packs 5 due to the freezing of the cool storage material is generated as shown in Fig. 22, the resilient plate 302 is deformed, so as to absorb the expansion, thereby preventing the packs 5 from being damaged. Furthermore, the resilient member 302 functions, also, to absorb a vibration generated due to the running of the refrigerated vehicle, thereby preventing the vibration from being transmitted to the cool storage packs 5, thereby preventing the plastic containers of the packs 5 from being damaged.

Now, a tenth embodiment of the present invention will be explained. The construction of the refrigerating system 1 for a refrigerated vehicle is the same as that shown in Fig. 1 with reference to the first embodiment. Fig. 23 shows a control panel of the tenth embodiment, which includes, in addition to the elements shown in Fig. 4 with reference to the first embodiment, a relay including a coil 47 and a normally opened relay switch 48 arranged parallel to the relay switch

45 of the relay 41 for controlling an on-off operation of the inner fan motor 32. A fixed resistor 49 is arranged in series to the relay contact 45. The resistor 49 is for obtaining a low rotational speed of the inside fan motor 32, i.e., a low air flow amount L_0 by the inside fan 31 when the relay switch 45 is made ON while the relay switch 48 is made OFF. Contrary to this, when the relay switch 48 is made ON, the resistor 49 is shunted, which causes the rotational speed of the inside fan motor 32 to be increased, thereby obtaining a large air flow amount H_1. Stoppage of the inside fan motor 32 is obtained when both of the relay switches 44 and 45 are made OFF.

In the embodiment, in place of the relay circuit as shown in Fig. 23 (Fig. 4), a semiconductor switching circuit may be used for operating the inside fan motor 32. Furthermore, in place of obtaining a step-like change in the rotational speed of the fan motor 32 (an air flow amount by the fan 31) by the step-like change in the electric current in the fan motor 32 due to the fixed resistor 49, a continuous change of the rotational speed of the inside fan motor 32 (continuous change in the air flow amount of the inside fan 31) can be obtained by a continuous change in the electric current by a continuously variable resistor.

Now, an operation of the tenth embodiment will be explained with reference to the flow chart in Fig. 24. This flowchart is similar to that in Fig. 5 except that steps S11, S12, S13 and S14 are provided. After the execution of the steps S1 and S2, as shown in Fig. 5, the routine goes to step S11, where a first, a second and a third values preset temperatures T1, T2 and T3 are calculated in accordance with the set temperature set by the inside temperature set switch. Then, the routine flows into steps S4 and S5. During a cool down operation after the cool storage or cool keeping operation, i.e., at the initial stage after the cool storage or cool keeping operation, the inside temperature Ta detected by the inside temperature sensor 37 would be higher than a third predetermined value T3 which is equal to the set inside temperature Ts plus predetermined value α such as 10°C. As a result, the cooling down operation would cause the routine to go to step S14, where the electromagnetic clutch 18 of the compressor 11 and the outside fan motor 34 are made ON, while the flow switching valve 17 is made OFF. Furthermore, the relay coil 41 is de-energized to cause the switch 45 to be made OFF, while the relay coil 47 is energized to make switch 48 ON, so that an increased electric current is obtained, thereby obtaining a high rotational speed Hi of the inside fan motor 32. Contrary to this, during the usual cooling operation, the inside temperature Ta is lower than the third predetermined value T3, which causes the result of the judgement at step S12 to be No, so that the routine goes to step S13, where the electromagnetic clutch 18 of the compressor 11 and the outside fan motor 34 are made ON, while the flow switching valve 17 is made OFF. Furthermore, the relay coil 41 is energized to cause the switch 45 to be made ON, while the relay coil 47 is de-energized to make switch 48 OFF. As a result, a reduced electric current is obtained due to the resistor 49, so that a low rotational speed Lo of the inside fan motor 32 is obtained. In this embodiment, the result of determination of NO at step S6 may directly lead to step S9.

In the tenth embodiment, the larger air flow amount Hi, larger than the normal value Lo, is obtained when the system is under a cool down operation. At the cool down operation, the temperature inside the refrigerating compartment 3 is higher than the set temperature Ts plus the predetermined value, i.e., the inside temperature Ta is higher than the set temperature T3. As result, the evaporating temperature of the refrigerant at the refrigerant evaporator becomes larger than the melting point of the cool storage material. As a result, in the cool storage packs 5, the cool storage material located adjacent the round tube 25 of the cool storage evaporator 14 is melted by a latent heat of melting of the cool storage material, which causes the enthalpy at the inlet of the refrigerant evaporator 15 to be reduced for a value of m in Fig. 25(C). Thus, in comparison with the normal refrigerating operation, an increased cooing capacity is obtained during the cooling down operation. Namely, in Fig.25, curve (a) is a Mollier diagram during the normal refrigerating operation, where a low speed rotation (a low flow amount L_0) of the inside fan 31 is obtained. In this case, a major portion j of the increase in the enthalpy during the evaporating periods is occupied by the cooling of the compartment. Curve (b) shows a Mollier diagram during the cool storage operation. In this case, the pressure is lowered and a major portion k of the increase in the enthalpy during the evaporating periods is occupied by the cool storage operation. Curve (c) shows a Mollier diagram during a high load operation, where a rotational speed of the fan is high, i.e., the air flow amount is as large as L_1. In this case, the pressure of the refrigerant is increased and the cool storage material is melted, which causes the enthalpy change n during the evaporating period to be increased.

The present invention can also be used for a refrigerating system for a stationary type container or refrigerator or for other any types of appliances with refrigerating capability.

Claims

1. A refrigerating system comprising:

a heat insulated chamber;

means for generating air flow recirculated in the chamber;

means arranged in the chamber for holding an amount of cool storage material;

a compressor for compressing refrigerant;

a condenser for receiving the compressed refrigerant from the compressor via an expansion valve for reducing the pressure of the refrigerant from the condenser;

a first evaporator for receiving the refrigerant of the reduced pressure for cooling the cool storage material;

a second evaporator for receiving the refrigerant of the reduced pressure for cooling the air flows recirculated in the chamber;

a closed passageway of the refrigerant being constructed by the compressor, the condenser, the temperature sensitive expansion valve, the first evaporator and the second evaporator;

said expansion valve being of a type capable of controlling the amount of the recirculated refrigerant in accordance with the temperature of the refrigerant at an outlet side of the second evaporator;

said first and second evaporators being arranged in series with each other;

the expansion valve being arranged in the closed passageway at a location upstream from the first evaporators, and;

means for obtaining switching between refrigerating condition where the flow of the recirculated air by means of the air flow generating means is obtained and a cool storage condition where the flow of the recirculated air by means of the air flow generating means is canceled.

2. A refrigerating system according to claim 1, wherein said switching means comprise sensor means, for detecting a temperature inside the chamber, and means for controlling the air flow generating means in such a manner that the latter is energized when the temperature inside the chamber is higher than a predetermined value and is de-energized when the temperature inside the chamber is lower than the predetermined value.

3. A refrigerating system according to claim 1, wherein the cool storage material has a solidifying temperature which is substantially the same as an evaporating temperature of the refrigerant when the temperature inside the chamber is reduced to a temperature lower than the predetermined value.

4. A refrigerating system according to claim 1, wherein it further comprises, in addition to the closed passageway, an additional passageway for connecting the recirculating passageway at a location between the compressor and the condenser with the recirculating passageway at a location between the first and second evaporators, and a switching means of obtaining a switching between a condition where the flow of the refrigerant along the closed passageway, i.e., the refrigerant from the compressor is passed through the condenser, the expansion valve and the first evaporator and is introduced into the second evaporator, and a condition where the refrigerant from the compressor is passed through the additional passageway and is introduced into the second evaporator.

5. A refrigerating system according to clam 1, wherein said temperature sensitive expansion valve comprises a first variable orifice in the recirculating passageway, a second variable orifice located downstream from the first orifice, and an actuator responsive to the temperature of the refrigerant at the outlet of the evaporators for controlling the first and second orifices in such a manner that, during the cool storage operation, an adiabatic expansion of the refrigerant occurs at the first orifice, while, during the refrigerating operation, an adiabatic expansion of the refrigerant occurs at the second orifice.

6. A refrigerating system according to claim 1, further comprising a sensor means for detecting a temperature inside the chamber, and means for controlling the air flow generating means in such a manner that an increased amount of the air flow is obtained when the temperature inside the chamber is higher than a predetermined value during the refrigerating operation.

7. A refrigerating system according to claim 1, further comprising a valve device located in the recirculating passageway at a location between the condenser and the evaporators, and a by-pass opening by-passing the valve device such that, during the cool storage operation, the valve is closed so that an adiabatic expansion of the refrigerant occurs at the by-pass opening but, during the refrigerating operation, an adiabatic expansion of the refrigerant occurs at the valve device.

8. A refrigerating system according to claim 1, further comprising means for obtaining switching between a refrigerating condition where the flow of the recirculated air by means of the air flow generating means is obtained and a cool keeping condition where the flow of the recirculated air by means of the air flow generating means is canceled while the compressor is stopped when a condition is obtained where the cool storage material is substantially fully solidified.

9. A refrigerating system comprising:

a heat insulated chamber;

means for generating a flow of air recirculated in the chamber;

means arranged in the chamber for holding an amount of cool storage material;

a compressor for compression of a refrigerant;

a condenser for receiving the compressed refrigerant from the compressor;

an expansion valve for reducing the pressure of the refrigerant from the condenser;

a first evaporator for receiving the refrigerant of the reduced pressure for cooling the cool storage material, and;

a second evaporator for receiving the refrigerant of the reduced pressure for cooling the air flow recirculated in the chamber;

a closed passageway of the refrigerant being constructed by the compressor, the condenser, the temperature sensitive expansion valve, the first evaporator and the second evaporator;

said expansion valve being of a type capable of controlling the amount of the recirculated refrigerant in accordance with the temperature of the refrigerant at an outlet side of the second evaporator;

said cool storage evaporator comprising a plurality of packs, each of which includes a container for storing therein a cool storage material, and a tube of a serpentine arrangement which is located in the refrigerant recirculating passageway and which is in contact with the cool storage material.

10. A refrigerating system according to claim 9, wherein said serpentine tube include portions projected out of and located below said packs.

11. A refrigerating system according to claim 9, wherein each of the packs is constructed by a first and second parts, which are connected with each other while the straight portions are arranged between the first and second parts.

12. A refrigerating system according to claim 9, wherein the cool storage packs are stored in a casing opened at the top, the casing having a closed bottom for receiving the serpentine tube, on which the packs are arranged, and a resilient plate is arranged at the top of the packs in the casing, so that the resilient plate is located between the packs and a wall of the chamber.

Fig.1

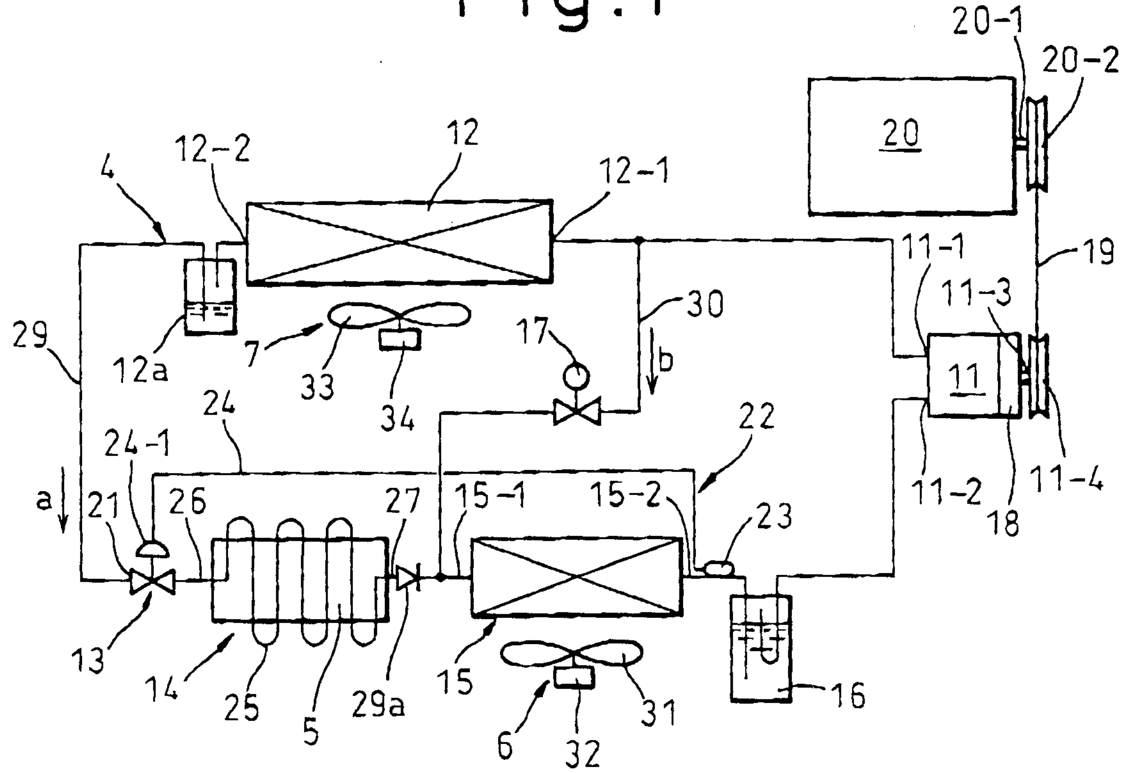

20-1
20-2
20
12
12-2
12-1
4
19
11-1
11-3
30
29
12a
7
33
34
17
b
11
24
22
11-2
11-4
18
24-1
a
21
26
27
15-1
15-2
23
13
14
25
5
29a
15
6
32
31
16

Fig.2

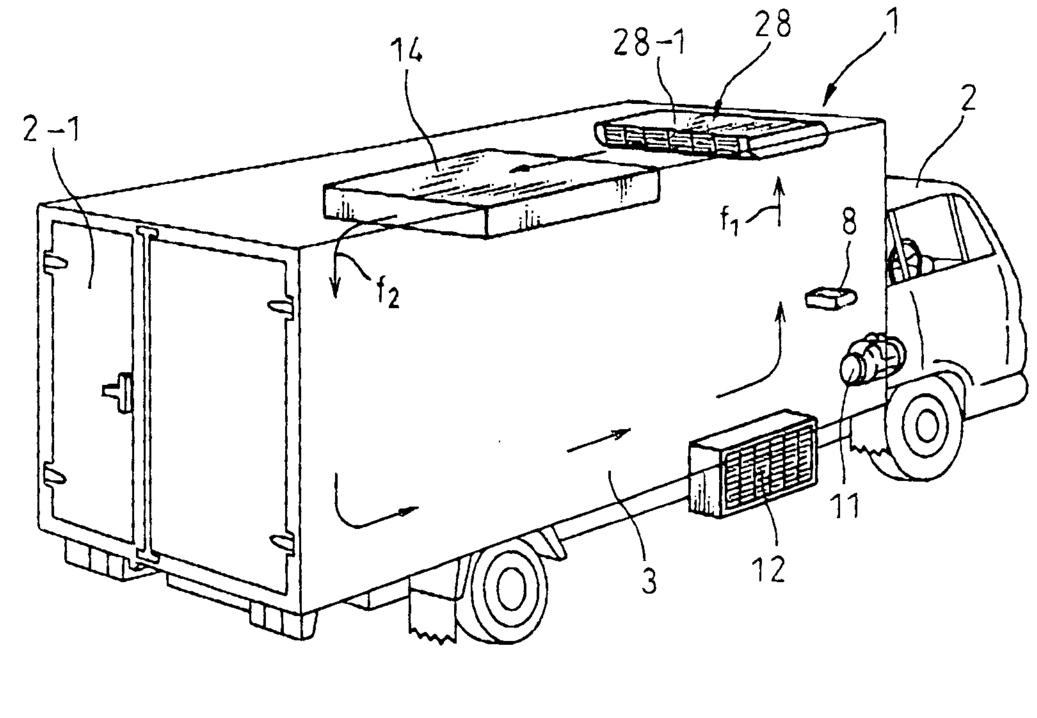

14
28-1
28
1
2
2-1
f1
f2
8
11
12
3

Fig.3

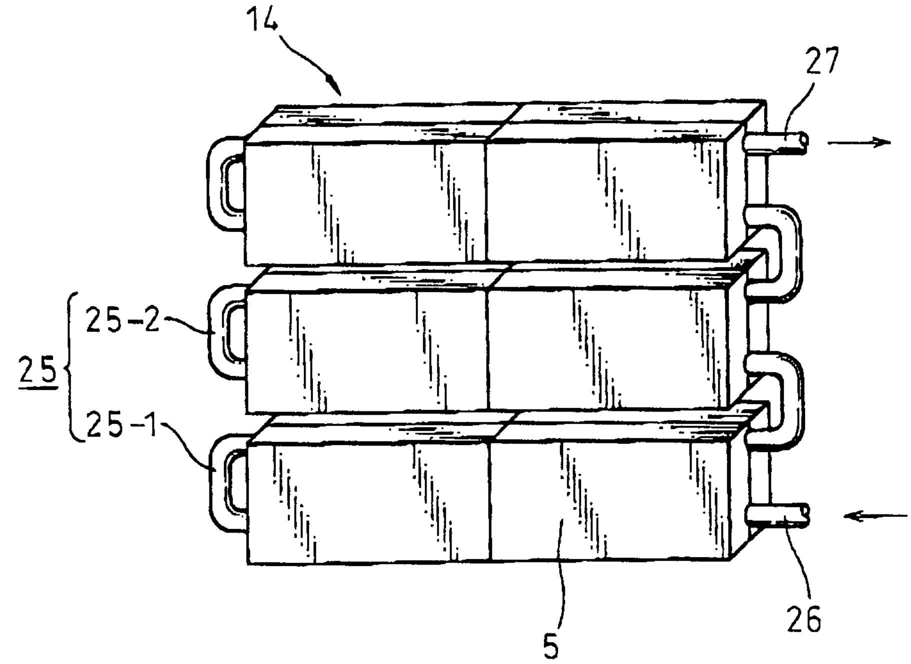

14
27
25-2
25
25-1
5
26

Fig.4

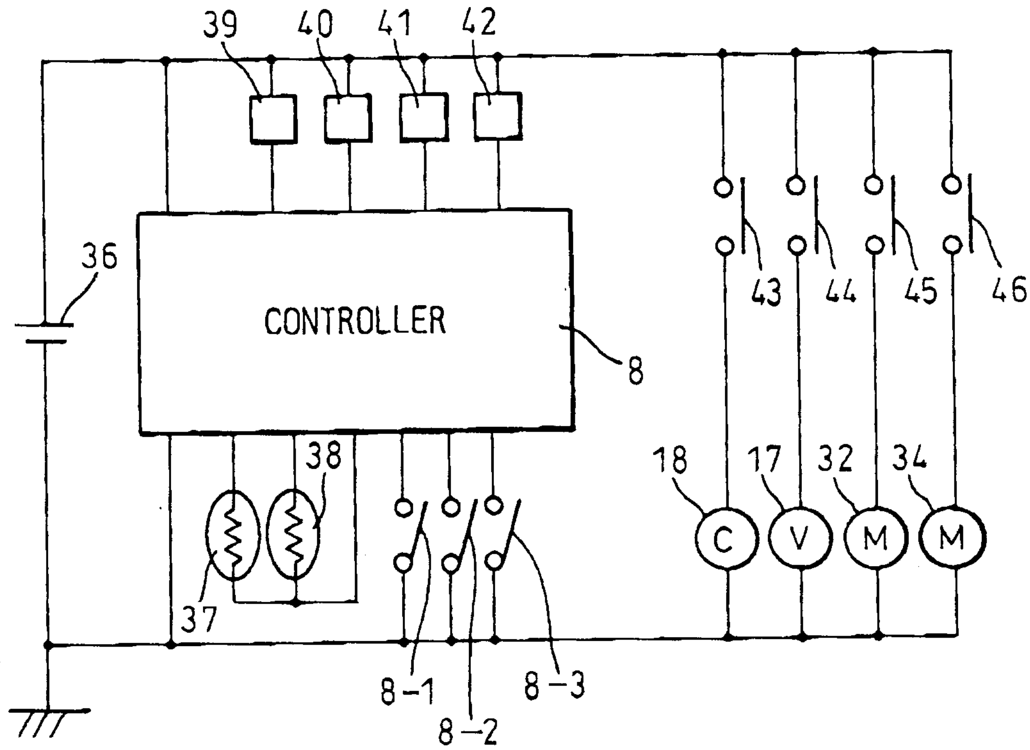
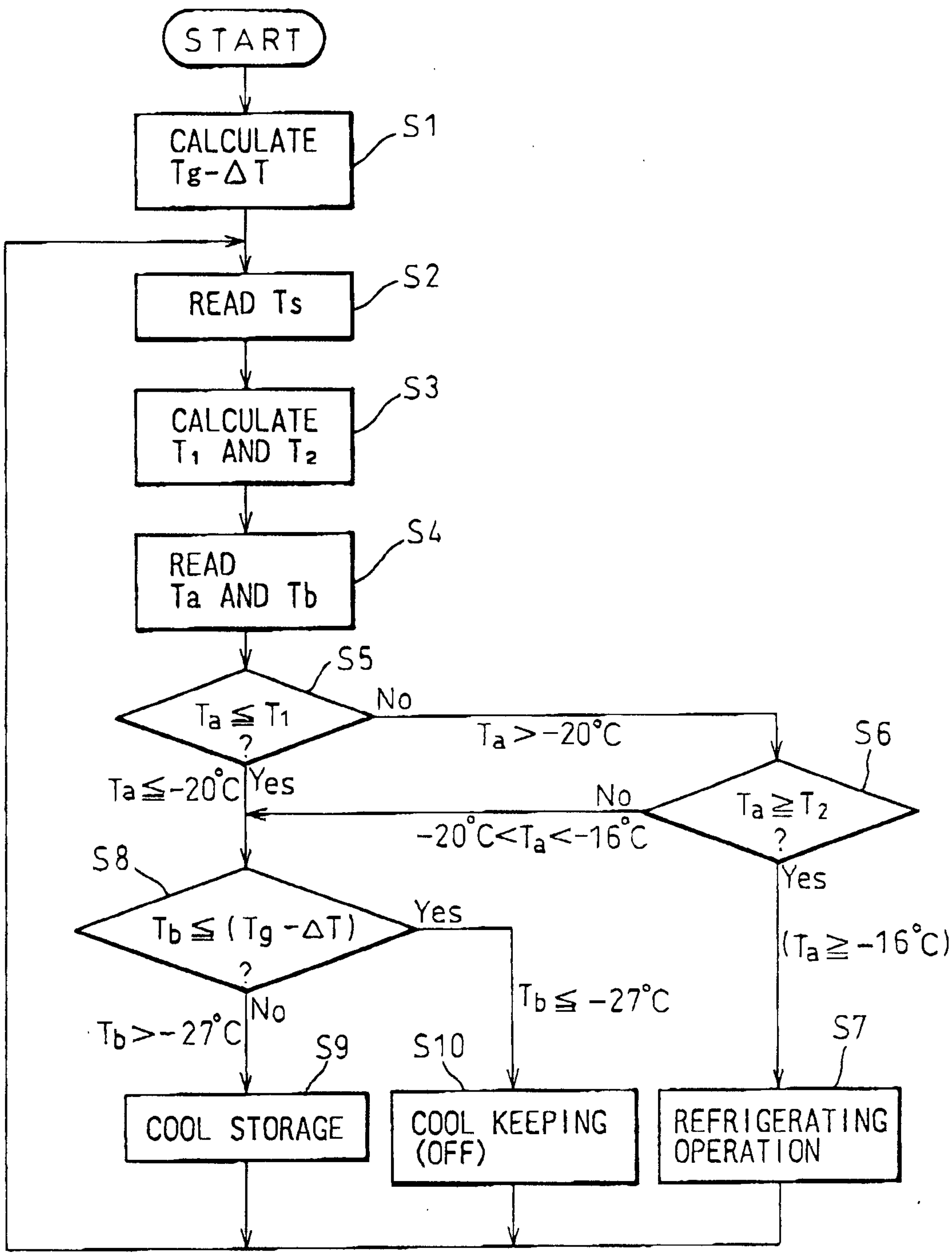

39
40
41
42
36
CONTROLLER
8
43
44
45
46
18
17
32
34
C
V
M
M
38
37
8-1
8-2
8-3

Fig.5


START
CALCULATE Tg−ΔT
S1
READ Ts
S2
CALCULATE T1 AND T2
S3
READ Ta AND Tb
S4
S5
Ta ≦ T1 ?
No
Ta > −20°C
S6
Ta ≧ T2 ?
Ta ≦ −20°C
Yes
No
−20°C < Ta < −16°C
Yes
(Ta ≧ −16°C)
S8
Tb ≦ (Tg −ΔT) ?
Yes
Tb ≦ −27°C
No
Tb > −27°C
S9
S10
S7
COOL STORAGE
COOL KEEPING (OFF)
REFRIGERATING OPERATION

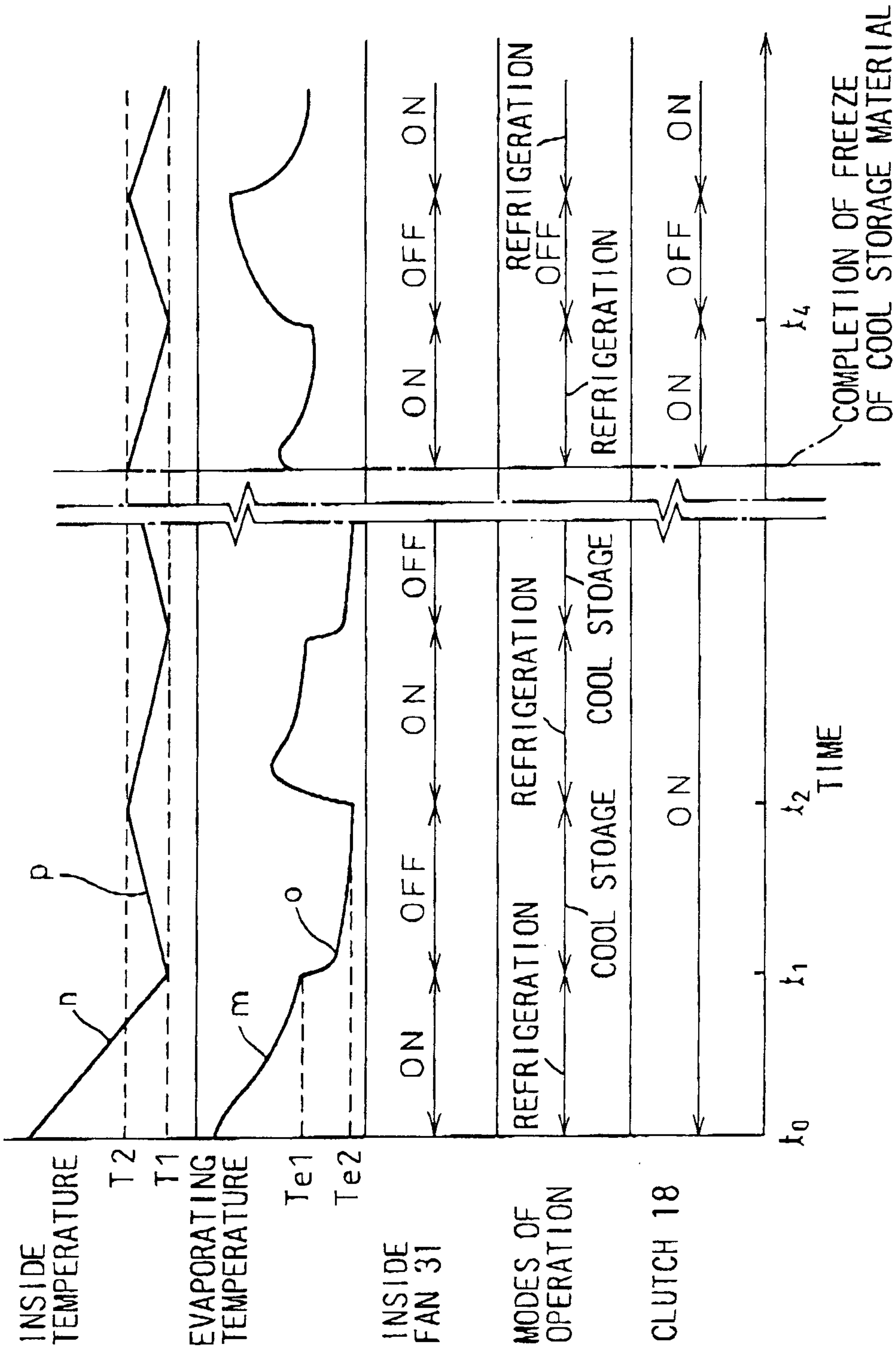


Fig.6A
Fig.6B
Fig.6C
Fig.6D
Fig.6E

Fig.7

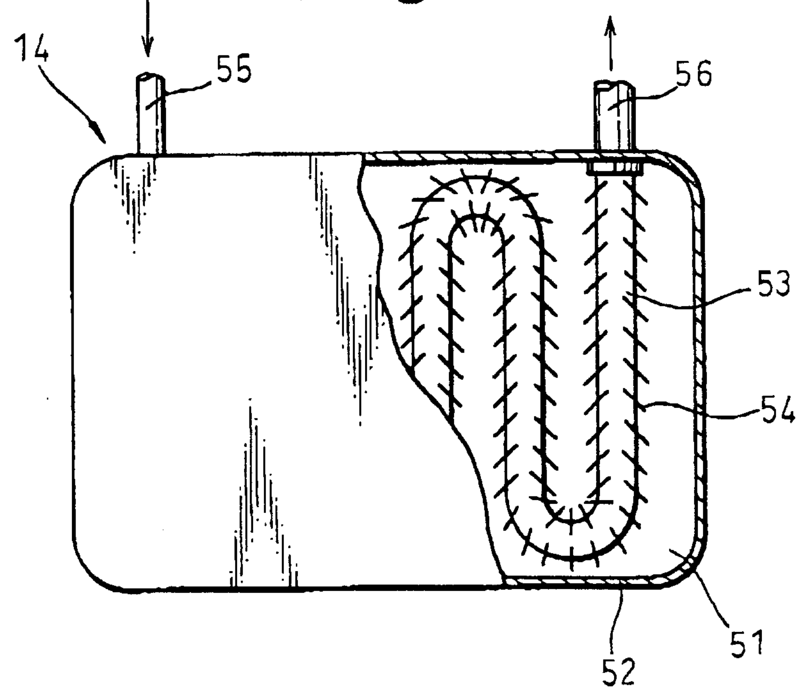


Fig.8

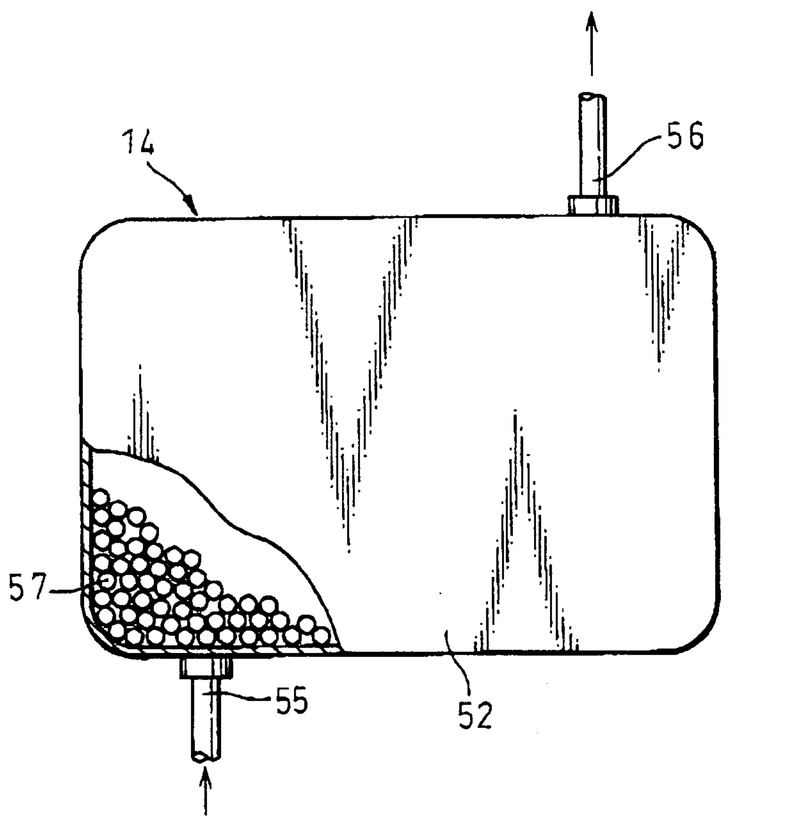


Fig.9

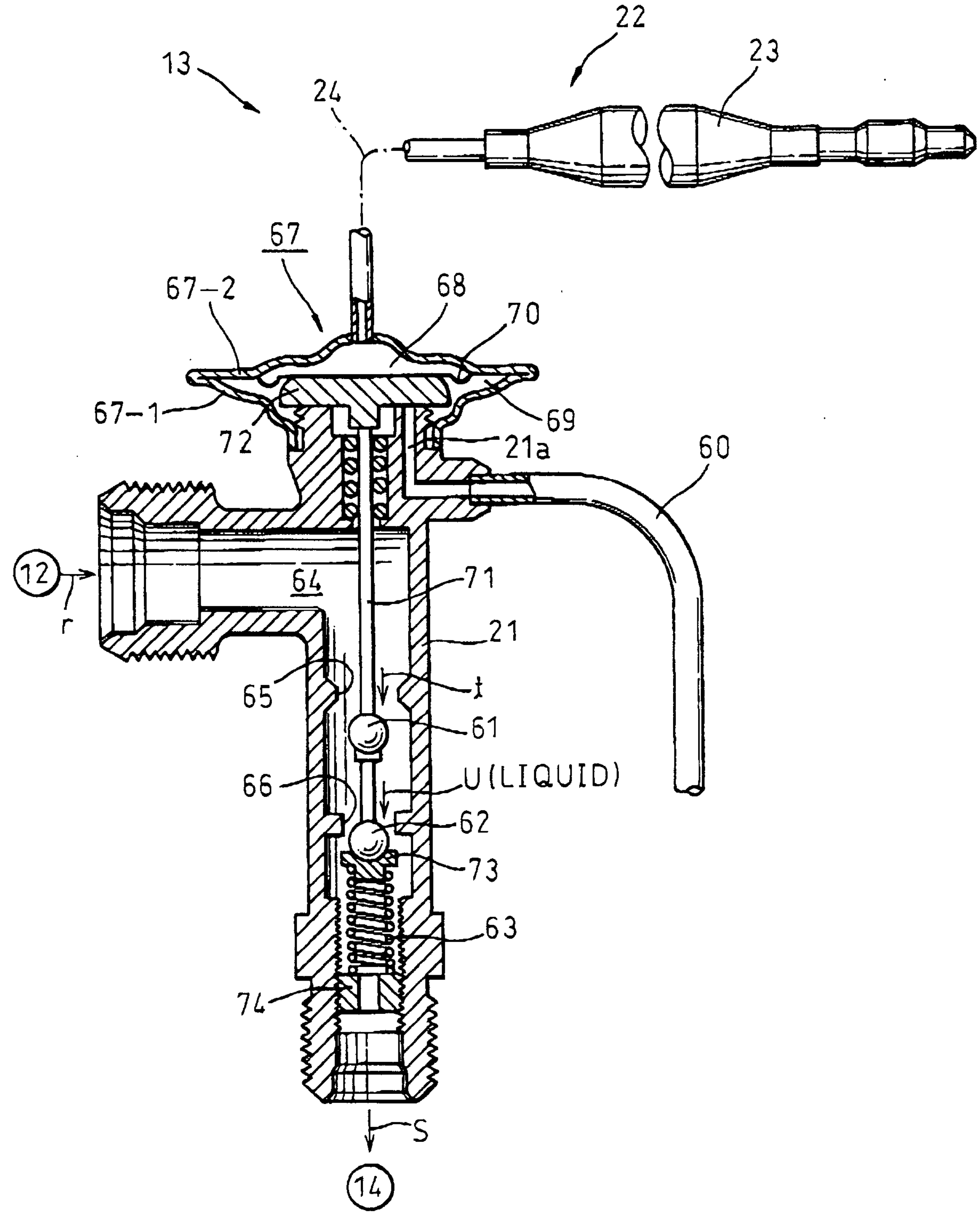

22
23
13
24
67
67-2
68
70
67-1
69
72
21a
60
12
r
64
71
21
65
t
61
66
U(LIQUID)
62
73
63
74
S
14

Fig.10

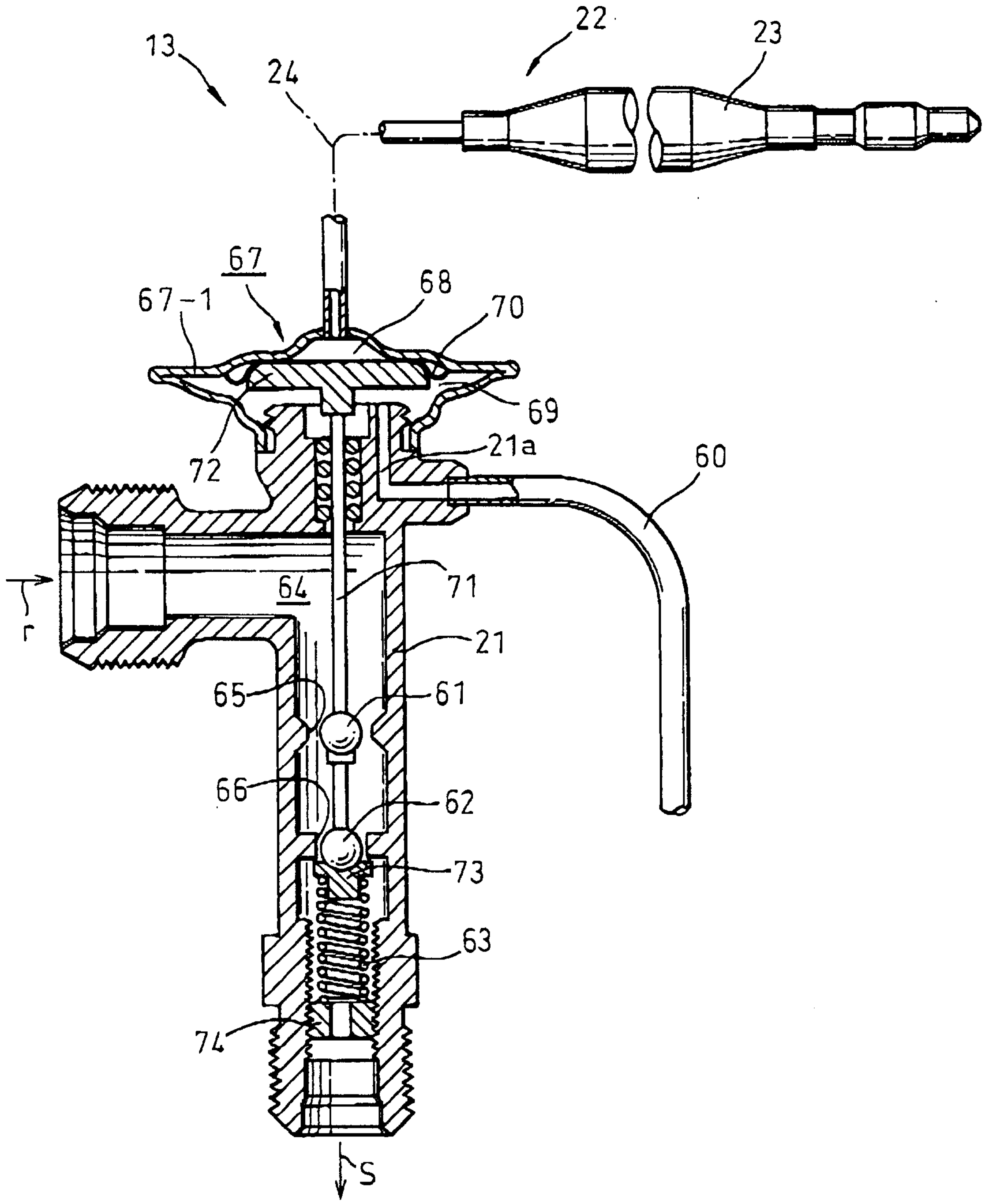


Fig.11

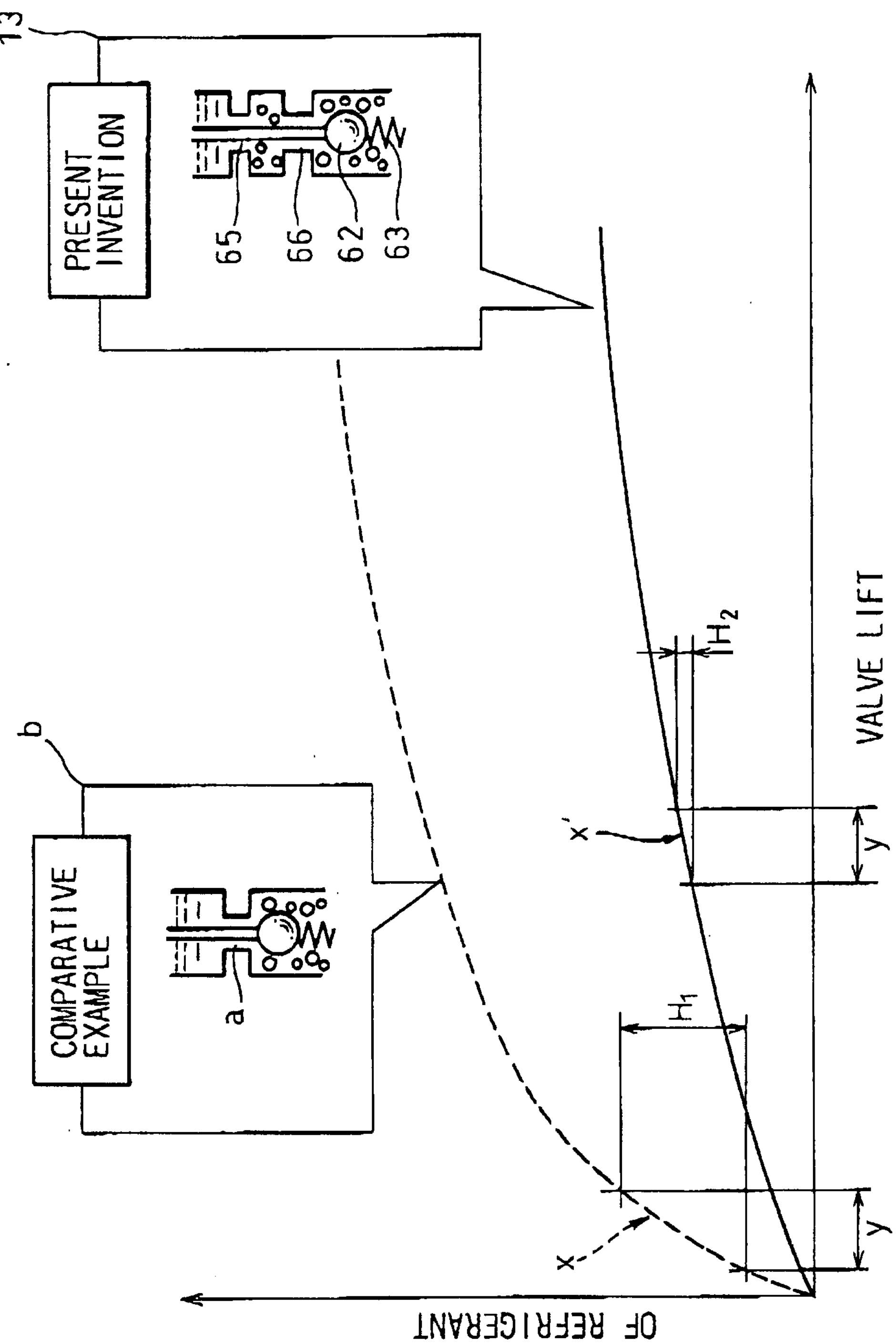
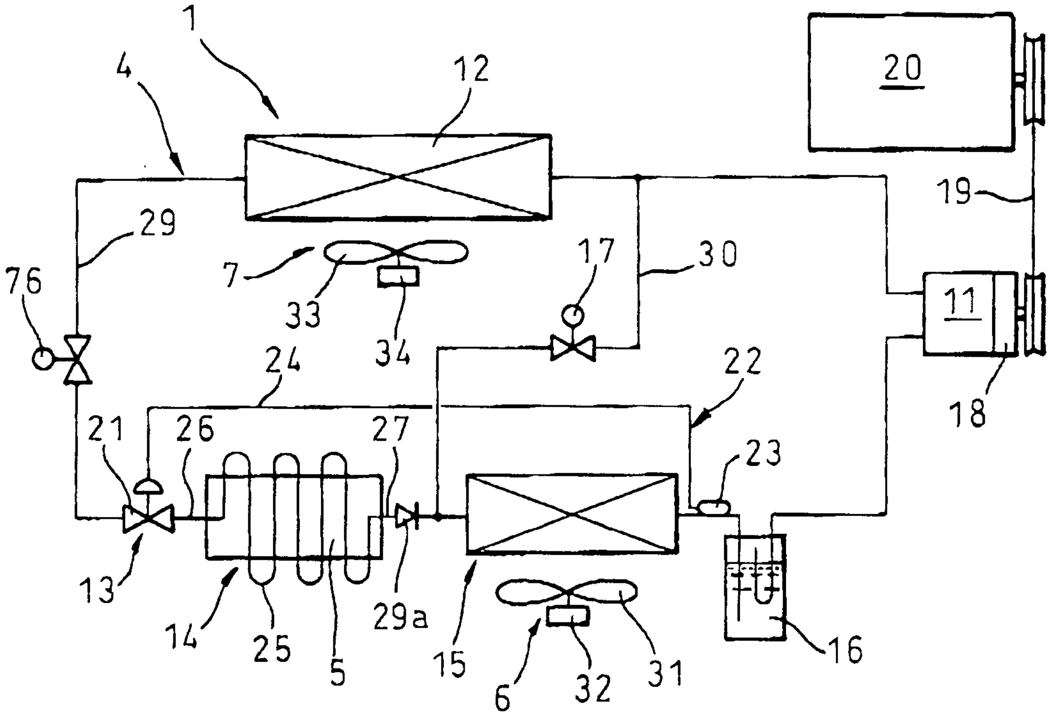

PRESENT INVENTION
13
65
66
62
63
COMPARATIVE EXAMPLE
b
a
x
x'
y
H1
H2
VALVE LIFT
RECIRCULATED AMOUNT OF REFRIGERANT

Fig.12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12
20
19
29
76
7
33
34
17
30
11
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18
21
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13
14
25
5
29a
15
6
32
31
16

Fig.13

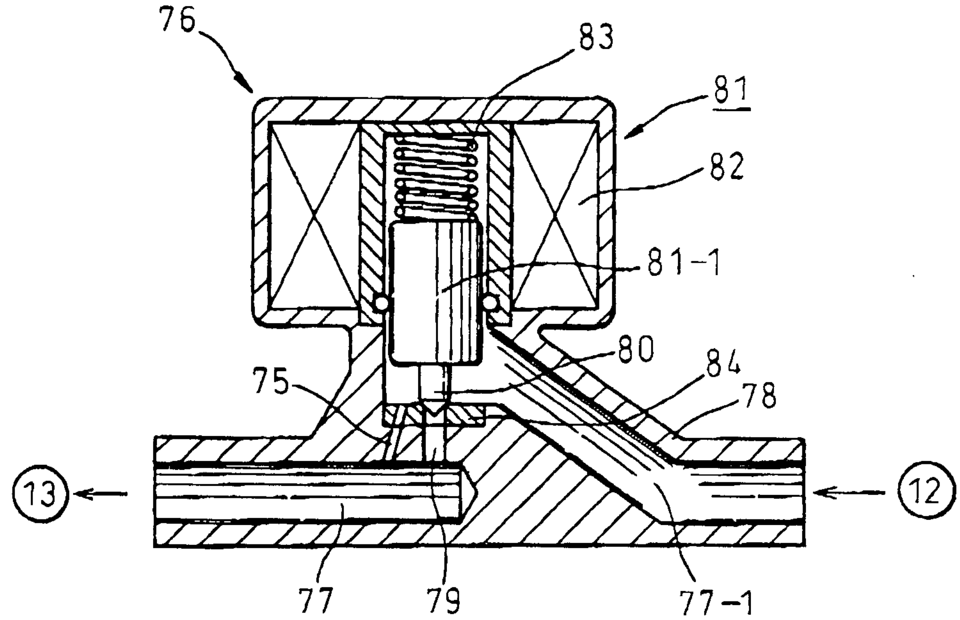

76
83
81
82
81-1
80
84
78
75
13
12
77
79
77-1

Fig.14

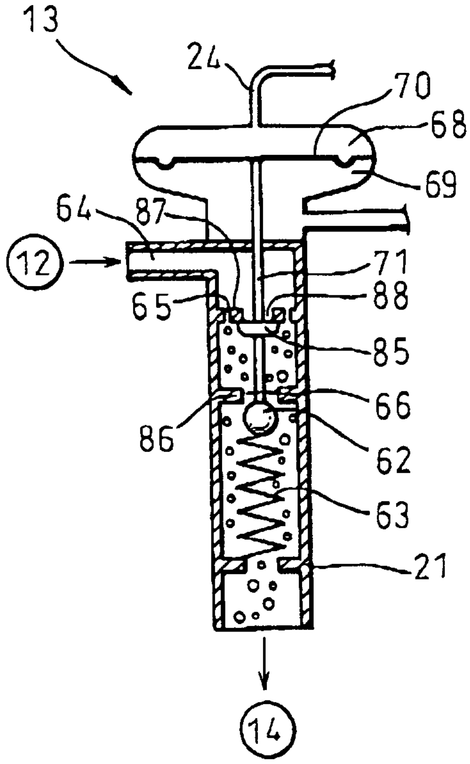
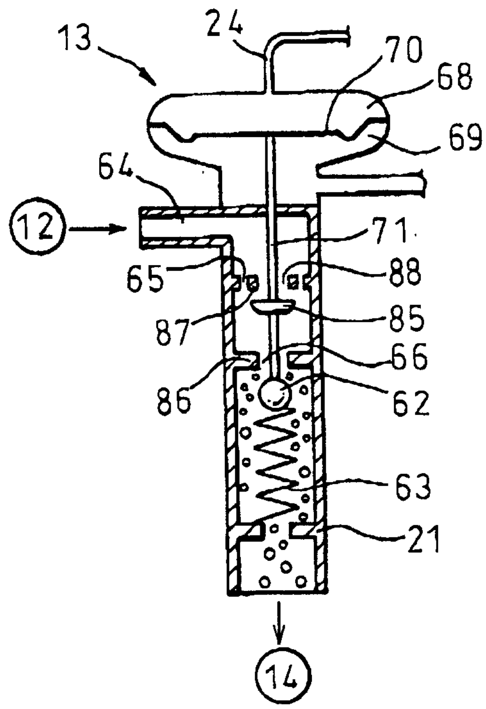

13
24
70
68
69
64
87
12
71
65
88
85
66
86
62
63
21
14

Fig.15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24
70
68
69
64
12
71
65
88
87
85
66
86
62
63
21
14

Fig.16

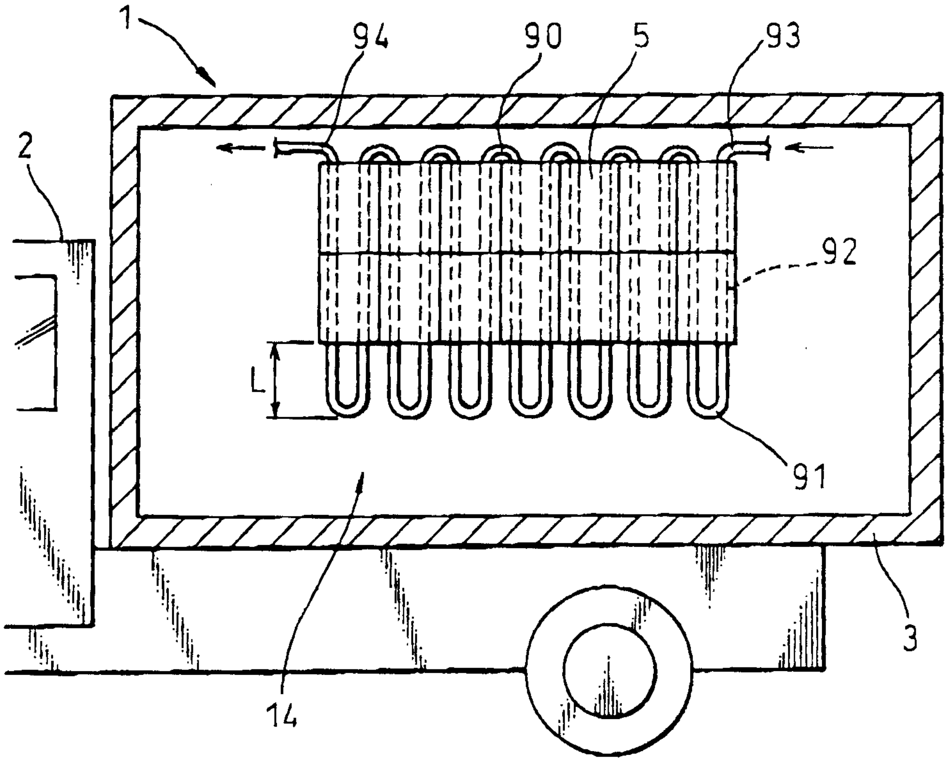


Fig.17

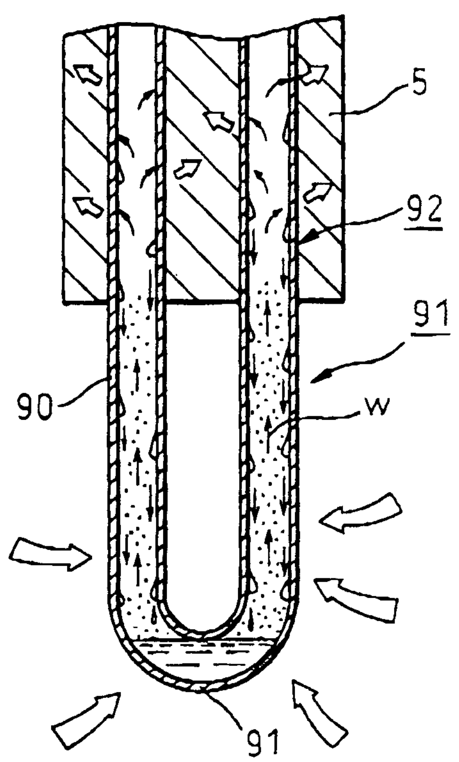


Fig.18

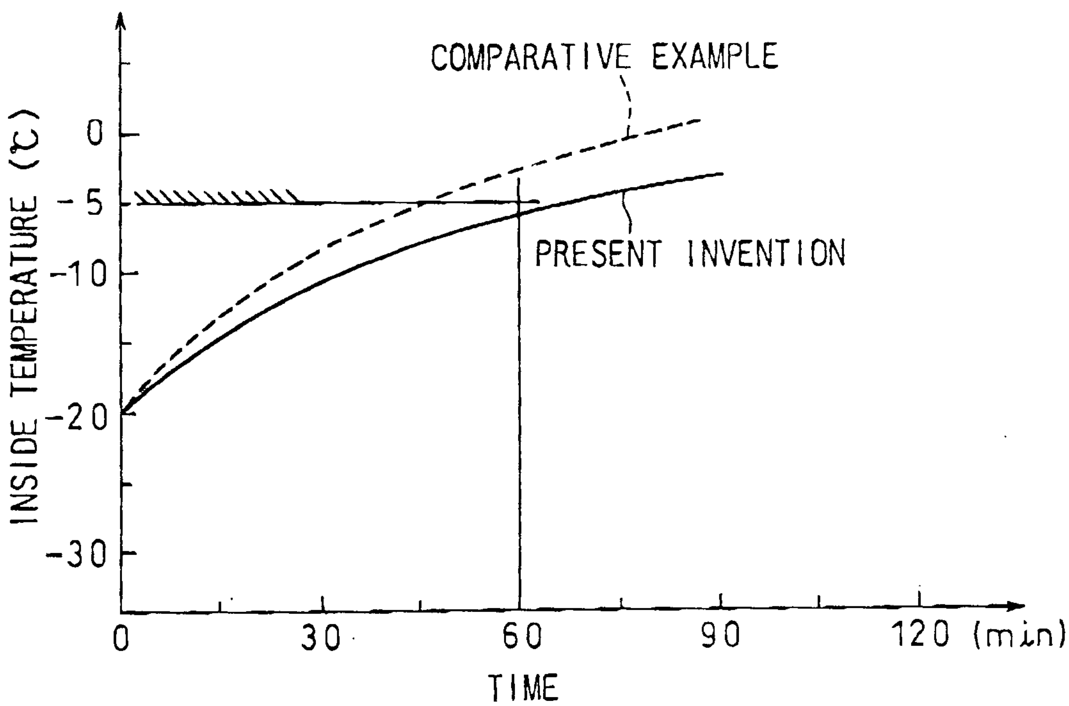

COMPARATIVE EXAMPLE
PRESENT INVENTION
INSIDE TEMPERATURE (℃)
0
-5
-10
-20
-30
0
30
60
90
120 (min)
TIME

Fig.19

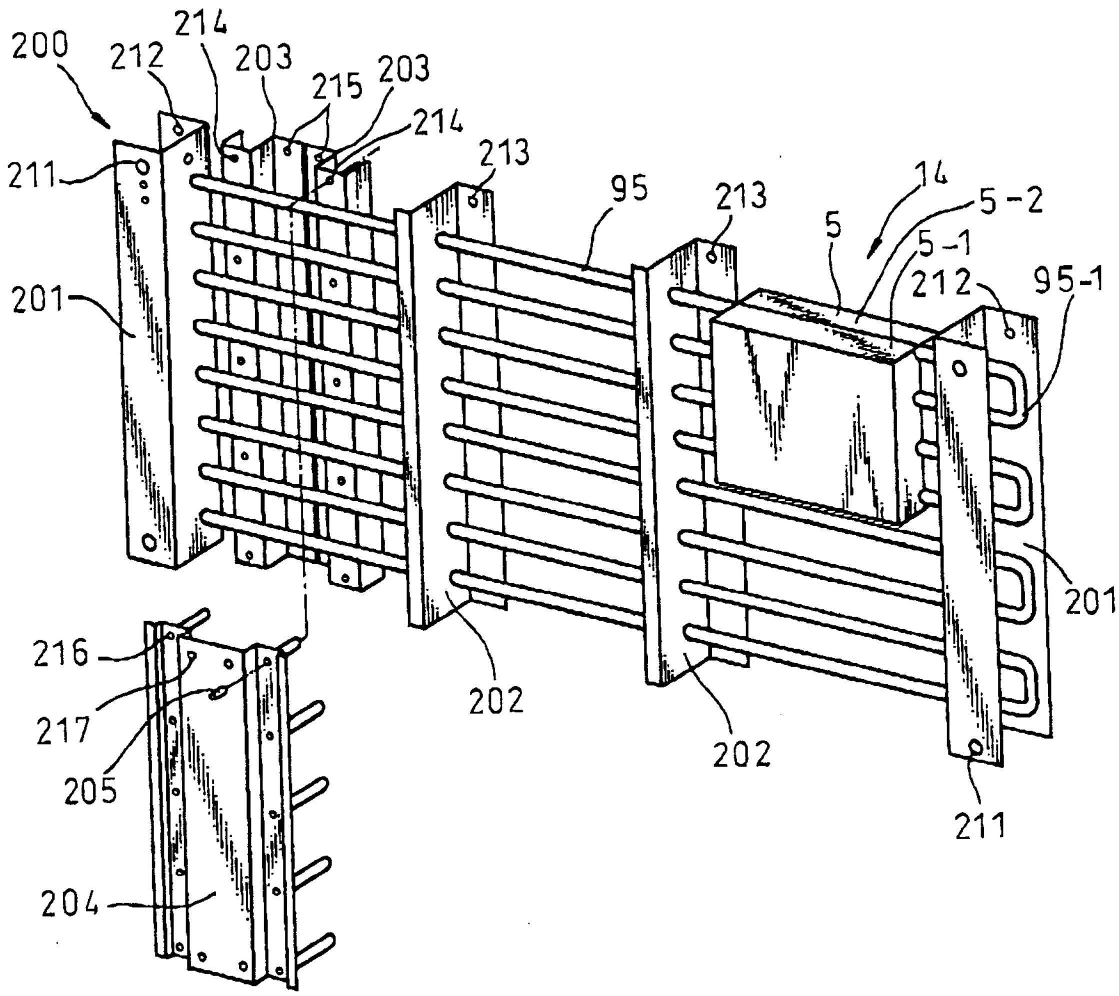

200
212
214
203
215
203
214
211
213
95
213
14
5-2
5
5-1
212
95-1
201
201
216
217
205
202
202
211
204

Fig.20

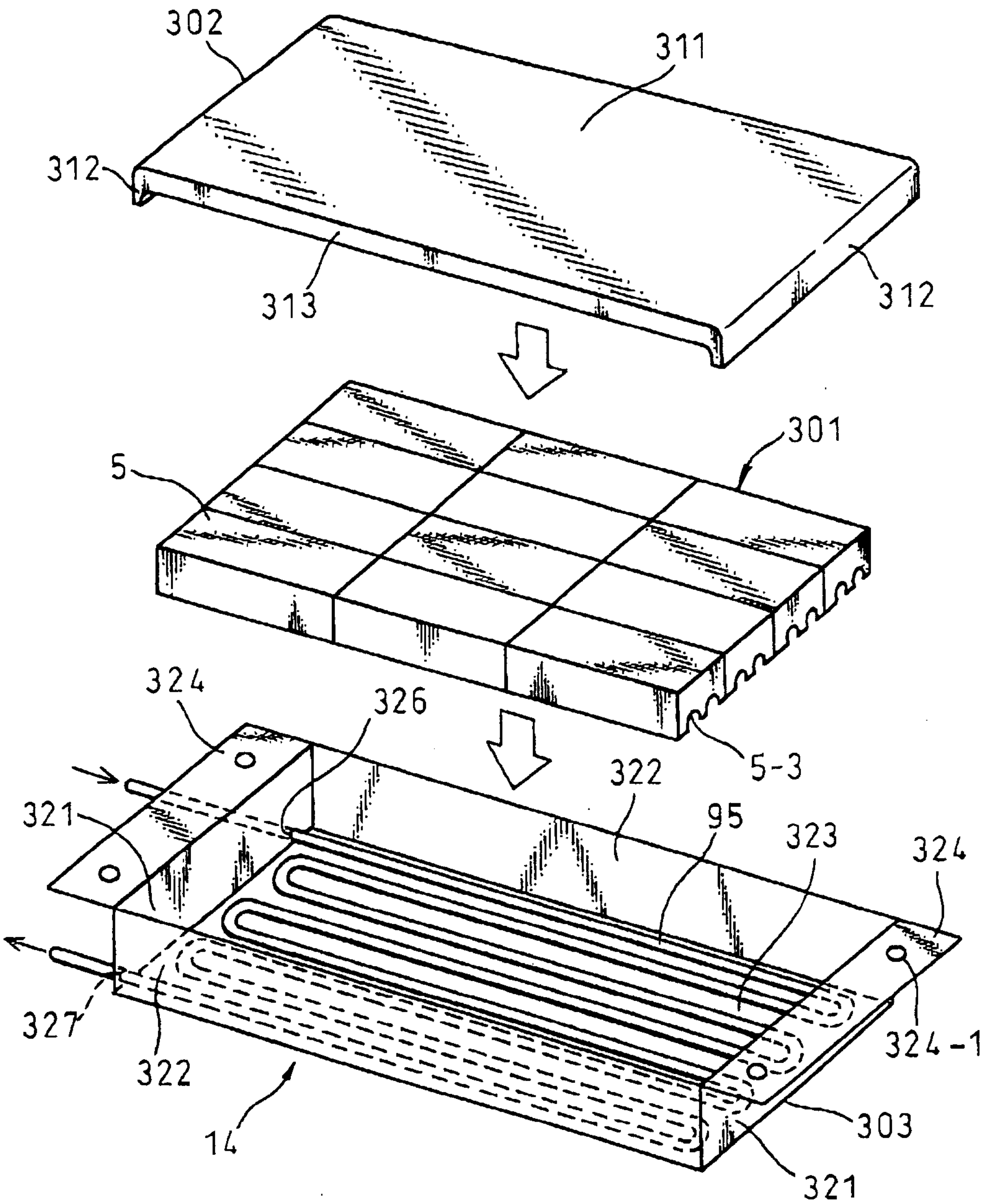

302
311
312
313
312
301
5
5-3
324
326
322
321
95
323
324
327
322
324-1
14
303
321

Fig.21

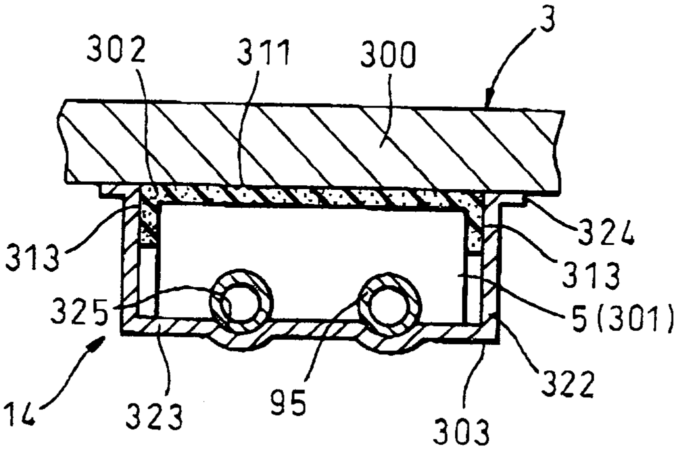

3
302
311
300
324
313
313
325
5(301)
322
14
323
95
303

Fig.22

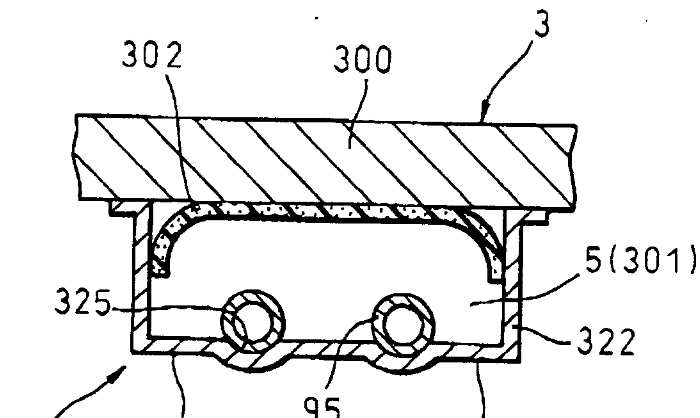

3
302
300
5(301)
325
322
14
323
95
303

Fig.23

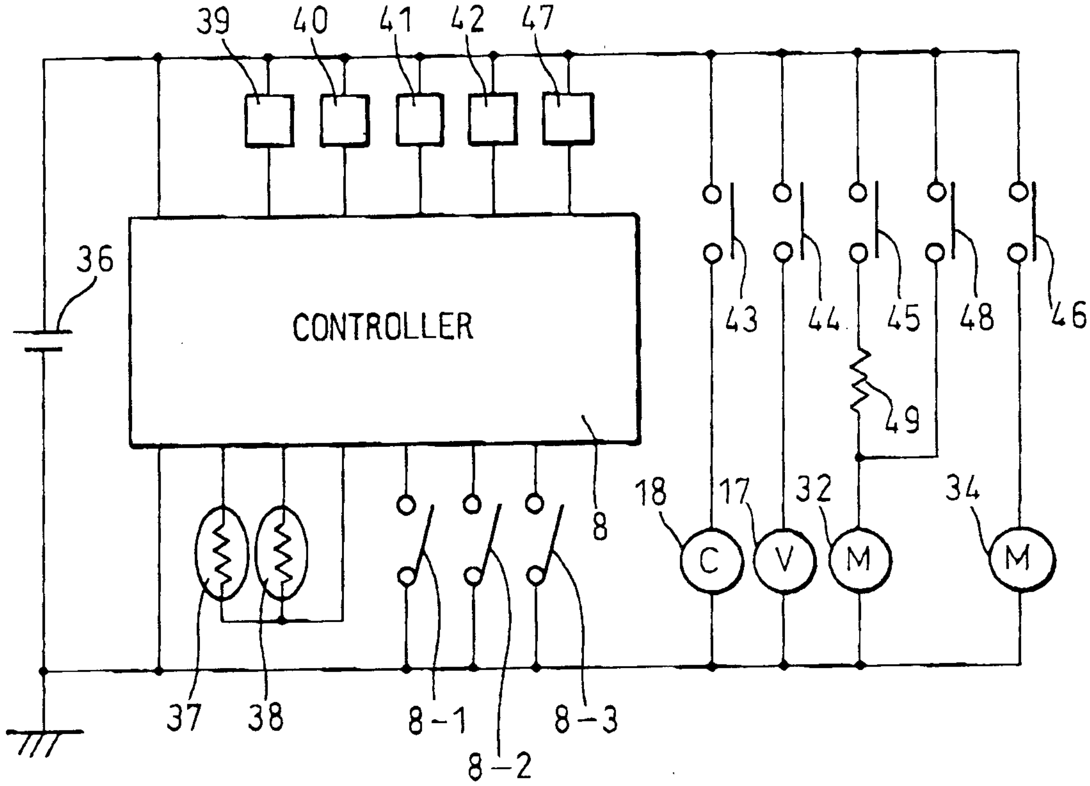

39
40
41
42
47
36
CONTROLLER
43
44
45
48
46
49
18
17
32
34
C
V
M
M
8
37
38
8-1
8-2
8-3

Fig. 24

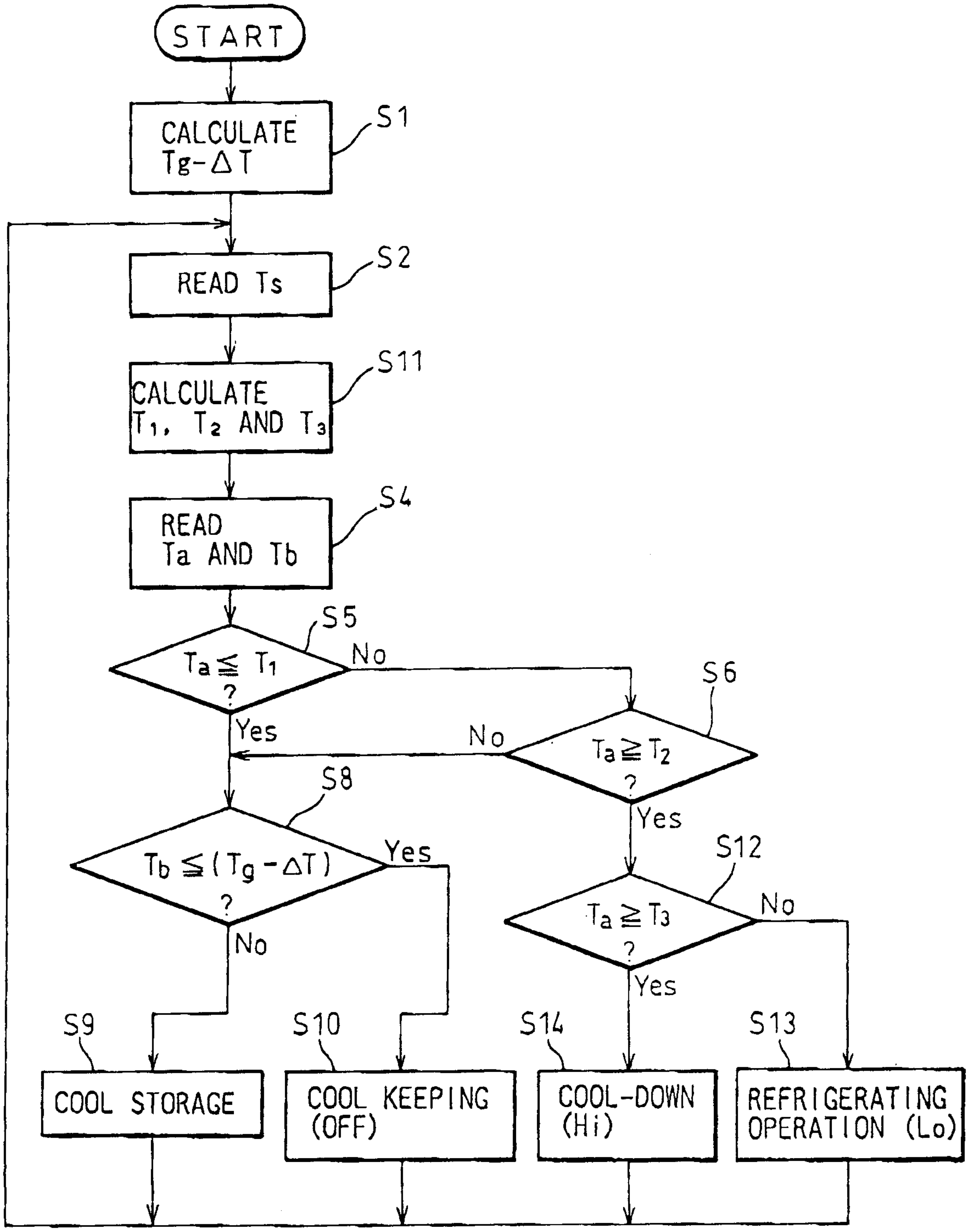
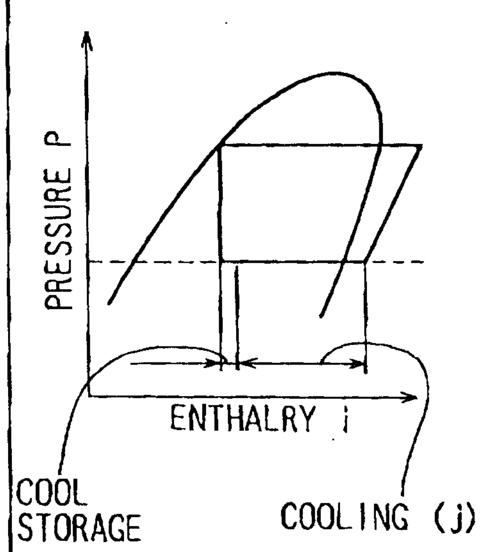
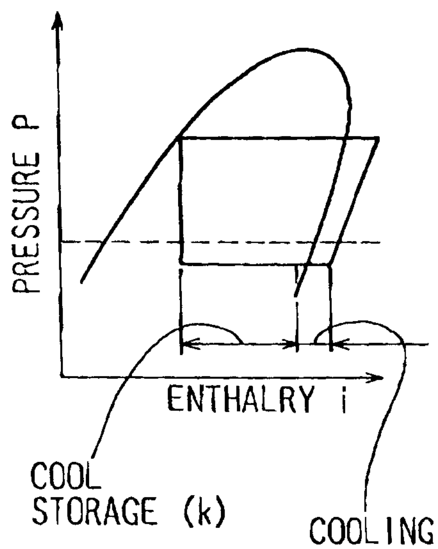

START
CALCULATE Tg-ΔT
S1
READ Ts
S2
CALCULATE T1, T2 AND T3
S11
READ Ta AND Tb
S4
Ta ≦ T1 ?
S5
No
Yes
Ta ≧ T2 ?
S6
No
Yes
Tb ≦ (Tg - ΔT) ?
S8
Yes
No
Ta ≧ T3 ?
S12
No
Yes
S9
COOL STORAGE
S10
COOL KEEPING (OFF)
S14
COOL-DOWN (Hi)
S13
REFRIGERATING OPERATION (Lo)

Fig.25

	NORMAL MODE		COOL-DOWN
	REFRIGERATING OPERATION	COOL STORAGE OPERATION	
INSIDE FAN	ON (SMALL AIR FLOW AMOUNT Lo)	OFF	ON (LARGE AIR FLOW AMOUNT Hi)
MOLLIER DIGAGRAM	(a) 	(b) 	(c)