An air-conditioning apparatus for a vehicle includes an evaporator and a temperature sensor for detecting the temperature of the evaporator. The evaporator includes three tube groups provided in a leeward tube row, and two tube groups provided in a windward tube row. The flow direction of refrigerant within heat exchange tubes of a farthest tube group of the leeward tube row farthest from a refrigerant inlet is the same as that within heat exchange tubes of a farthest tube group of the windward tube row farthest from a refrigerant outlet. A single path is formed by the two farthest tube groups. The temperature sensor is disposed to detect the temperature of a portion of the evaporator where the farthest tube group of the leeward tube row is provided. The air-conditioning apparatus prevents the temperature of air from greatly changing due to turning on and off of a compressor.
Fig. 3
AIR-CONDITIONING APPARATUS FOR VEHICLE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an air-conditioning apparatus for a vehicle, which is a refrigeration cycle to be mounted on an automobile, for example.

[0002] Herein in and in the appended claims, the upper and lower sides of FIGS. 2 and 3 will be referred to as "upper" and "lower," respectively.

[0003] A widely known air-conditioning apparatus for a vehicle (hereinafter may be referred to as a "vehicular air-conditioning apparatus") includes a compressor which uses an engine as a drive source and is connected to the engine through clutch means; a condenser for cooling refrigerant compressed by the compressor; a pressure reducer for reducing the pressure of the refrigerant cooled by the condenser; an evaporator for evaporating the refrigerant whose pressure has been reduced by the pressure reducer; and a temperature sensor for detecting the temperature of the evaporator. The vehicular air-conditioning apparatus controls the temperature of the evaporator by means of turning the compressor on and off on the basis of the temperature detected by the temperature sensor, to thereby prevent generation of a large difference between the temperature of air blown out into a vehicle cabin when the compressor is on (i.e., operated) and the temperature of air blown out into the vehicle cabin when the compressor is off (i.e., not operated).

[0004] Such a vehicular air-conditioning apparatus proposed in the past (see Japanese Patent Application Laid-Open (kokai) No. 2004-268769) has the following structure. The evaporator of the vehicular air-conditioning apparatus includes two tube rows juxtaposed in an air-passing direction. Each tube row includes a plurality of heat exchange tubes which are disposed such that their longitudinal directions coincide with the vertical direction and they are spaced from one another in a direction orthogonal to the air-passing direction. A fin is disposed to extend over an air-passing gap between adjacent heat exchange tubes of one tube row and over an air-passing gap between corresponding adjacent heat exchange tubes of the other tube row such that the fin is shared by the heat exchange tubes of the two tube rows. Upper and lower end portions of the heat exchange tubes of the leeward tube row are connected to leeward upper and lower header sections, respectively, and upper and lower end portions of the heat exchange tubes of the windward tube row are connected to windward upper and lower header sections, respectively. A refrigerant inlet is provided at one end of the leeward upper header section, and a refrigerant outlet is provided at one end of the windward upper header section, which end is located on the same side as the one end of the leeward upper header section. The leeward tube rows includes first through fourth tube groups each composed of a plurality of heat exchanges and arranged in this order from the refrigerant inlet side toward the opposite end side. The windward tube row includes fifth through eighth tube groups each composed of a plurality of heat exchanges and arranged in this order from the end opposite the refrigerant outlet toward the refrigerant outlet. The eighth tube group is located windward of the first tube group, the seventh tube group is located windward of the second tube group, the sixth tube group is located windward of the third tube group, and the seventh tube group is located windward of the fourth tube group. Each tube group forms a single path. In each tube group, the refrigerant flows through the heat exchange tubes in the same direction. The refrigerant flow direction of the heat exchange tubes of a certain tube group is opposite the refrigerant flow direction of the heat exchange tubes of another tube group adjacent to the certain tube group. A first temperature sensor is attached to a fin disposed between adjacent heat exchange tubes of the first tube group, and a second temperature sensor is attached to a fin disposed between adjacent heat exchange tubes of the fourth tube group.

[0005] In the vehicular air-conditioning apparatus described in the above-mentioned publication, when the temperature of the fins disposed in the first tube group of the evaporator detected by the first temperature sensor becomes equal to or lower than an off-side target temperature, the clutch means is brought into a disconnected or disengaged state so as to stop the compressor, and, when the temperature of the fins disposed in the fourth tube group of the evaporator detected by the second temperature sensor elevates to an on-side target temperature higher than the off-side target temperature by a predetermined temperature, the clutch means is brought into a connected or engaged state so as to return the compressor to the operated state.

[0006] However, since a super heat region is present in the eighth tube group, when the compressor is off, the temperature of the fins disposed in the eighth tube group of the evaporator becomes considerably high. Accordingly, when the compressor is turned on, a relatively long period of time is required for the temperature of the fins disposed in the first tube group of the evaporator to become equal to or lower than the off-side target temperature, and the temperatures of the heat exchange tubes and the fins disposed in other tube groups (e.g., the fourth and fifth tube groups) of the evaporator decrease. In such a case, condensed water may freeze. As a result of freezing of condensed water, an offensive smell called "freezing odor" may be produced.

[0007] Also, since the vehicular air-conditioning apparatus disclosed in the above-mentioned publication uses two temperature sensors, the number of components increases, which results in an increase in cost and an increase in the number of man-hours of assembling operation. In addition, its control system may become complex.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to solve the above-described problem and to provide an air-conditioning apparatus for a vehicle which can prevent freezing of condensed water on the surface of an evaporator and which can reduce the number of components.

[0009] To achieve the above object, the present invention comprises the following mode.

[0010] 1) An air-conditioning apparatus for a vehicle comprising a compressor which uses an engine as a drive source and is connected to the engine through clutch means; a condenser for cooling refrigerant compressed by the compressor; a pressure reducer for reducing the pressure of the refrigerant cooled by the condenser; an evaporator for evaporating the refrigerant whose pressure has been reduced by the pressure reducer; and a temperature sensor for detecting the temperature of the evaporator, the air-conditioning apparatus controlling the temperature of the evaporator by turning the compressor on and off on the basis of the temperature detected by the temperature sensor. The evaporator includes leeward and windward tube rows which are juxtaposed in an air-passing direction and each of which is composed of a plurality of heat
exchange tubes disposed at predetermined intervals in a direction orthogonal to the air-passing direction such that their longitudinal directions coincide with a vertical direction. The leeward tube row includes three or more tube groups each composed of a plurality of heat exchange tubes, and the windward tube row includes tube groups the number of which is one less than the number of the tube groups of the leeward tube row and each of which is composed of a plurality of heat exchange tubes. Upper and lower ends of the heat exchange tubes of the leeward tube row communicate with leeward upper and lower header sections, respectively, and upper and lower ends of the heat exchange tubes of the windward tube row communicate with windward upper and lower header sections, respectively. A refrigerant inlet is provided at one end of one leeward header section selected from the leeward upper and lower header sections, and a refrigerant outlet is provided at one end of one windward header section selected from the windward upper and lower header sections in such a manner that the refrigerant outlet and inlet are located side by side in the air-passing direction. A flow direction of refrigerant within the heat exchange tubes of a farthest tube group of the leeward tube row located at a position farthest from the refrigerant inlet is the same as a flow direction of refrigerant within the heat exchange tubes of a farthest tube group of the windward tube row located at a position farthest from the refrigerant outlet. A single path is formed by the two farthest tube groups which are juxtaposed in the air-passing direction and which are the same in the flow direction of refrigerant within the heat exchange tubes. A single temperature sensor is disposed on the evaporator so as to detect the temperature of a portion of the evaporator where the farthest tube group of the leeward tube row is provided.

[0011] 2) An air-conditioning apparatus for a vehicle according to par. 1), wherein the temperature sensor is composed of a thermistor, and is attached to a fin disposed between adjacent heat exchange tubes of the farthest tube group of the leeward tube row.

[0012] 3) An air-conditioning apparatus for a vehicle according to par. 1), wherein first through third tube groups each composed of a plurality of heat exchange tubes are provided in the leeward tube row of the evaporator in such a manner that the first through third tube groups are arranged in this order from one end of the leeward tube row on the refrigerant inlet side toward the other end of the leeward tube row; fourth and fifth tube groups each composed of a plurality of heat exchange tubes are provided in the windward tube row of the evaporator in such a manner that the fourth and fifth tube groups are arranged in this order from one end of the windward tube row opposite the refrigerant outlet toward the other end of the windward tube row located on the refrigerant outlet side; a predetermined number of sections are provided in each of the leeward upper and lower header sections and the windward upper and lower header sections, whereby the first tube group serves as a first path where the refrigerant flows within the heat exchange tubes from one of upper and lower sides where the refrigerant inlet is located to the opposite side, the second tube group serves as a second path where the refrigerant flows within the heat exchange tubes in a direction opposite the flow direction in the first path, the third and fourth tube groups serve as a third path where the refrigerant flows within the heat exchange tubes in the same direction as the flow direction in the first path, and the fifth tube group serves as a fourth path where the refrigerant flows within the heat exchange tubes in the direction opposite the flow direction in the first path; and the third and fourth tube groups which are the same in the flow direction of the refrigerant within the heat exchange tubes are juxtaposed in the air-passing direction.

[0013] According to the air-conditioning apparatus for a vehicle of paras. 1) through 3), the refrigerant having flowed into the evaporator through the refrigerant inlet thereof flows over substantially the same period of time and the same distance before reaching the farthest tube group of the leeward tube row and before reaching the farthest tube group of the windward tube row. Therefore, when the compressor is switched from the off state to the on state, the heat exchange tubes of the two farthest tube groups of the evaporator are cooled uniformly. As a result, when the compressor is turned on, the temperature of a portion of the evaporator where the third tube group is present becomes equal to or lower than an off-side target temperature within a relatively short period of time. Accordingly, it is possible to prevent occurrence of a problem in that the temperature of a portion of the evaporator where the tube groups, excluding the farthest tube group of the leeward tube row and the farthest tube group of the wind tube row, are present decreases, and condensed water freezes. As a result, production of an offensive smell called freezing odor, which is produced as a result of freezing of condensed water, can be restrained.

[0014] Also, when the compressor is switched from the off state to the on state, the temperature of a portion of the evaporator where the nearest tube group of the leeward tube row closest to the refrigerant inlet is present is apt to decrease sharply. However, the decrease in the temperature of the portion of the evaporator where the nearest tube group of the leeward tube row is present, which decrease occurs when the compressor is switched from the off state to the on state, is mitigated for the following reason. When the compressor is off, due to presence of a super heat region in the nearest tube group of the windward tube row closest to the refrigerant outlet, the temperature of a portion of the evaporator where the nearest tube group of the windward tube row is present becomes considerably high. This high temperature mitigates the decrease in the temperature of the portion of the evaporator where the nearest tube group of the leeward tube row is present. Accordingly, when the compressor is on, the decrease in the temperature of the portion of the evaporator where the nearest tube group of the leeward tube row is present is restrained, whereby freezing of condensed water is restrained.

[0015] Also, since the air-conditioning apparatus for a vehicle of paras. 1) through 3) uses a single temperature sensor only, the number of components decreases. Therefore, cost can be lowered, and the number of man-hours of assembling operation can be decreased. In addition, the control system of the air-conditioning apparatus becomes simple.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0016]** FIG. 1 is a partially cut-away perspective view showing the overall structure of an evaporator used in an air-conditioning apparatus for a vehicle of the present invention;
**[0017]** FIG. 2 is a partially omitted sectional view taken along line A-A of FIG. 1;
**[0018]** FIG. 3 is a partially omitted sectional view taken along line B-B of FIG. 1; and
**[0019]** FIG. 4 is a view showing the flow of refrigerant in the evaporator of FIG. 1.
DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] An embodiment of the present invention will next be described with reference to the drawings. In the embodiment to be described later, air flows in a direction indicated by an arrow X in the drawings, passes through an evaporator, and is fed into the cabin of a vehicle on which a vehicular air-conditioning apparatus is mounted.

[0021] In the following description, the left and right sides when viewed from the leeward side toward the windward side (the left and right sides of FIGS. 2 and 3) will be referred to as “left” and “right,” respectively.

[0022] The term “aluminum” as used in the following description encompasses aluminum alloys in addition to pure aluminum.

[0023] FIG. 1 shows the overall structure of an evaporator used in a vehicular air-conditioning apparatus of the present invention, FIGS. 2 and 3 schematically show the structure of the evaporator, and FIG. 4 shows the flow of refrigerant in the evaporator of FIG. 1. Notably, since the structure of the vehicular air-conditioning apparatus is well known, it is not shown in the drawings.

[0024] The vehicular air-conditioning apparatus includes a compressor which uses an engine as a drive source and is connected to the engine through clutch means; a condenser for cooling refrigerant compressed by the compressor; a pressure reducer for reducing the pressure of the refrigerant cooled by the condenser; an evaporator 1 for evaporating the refrigerant whose pressure has been reduced by the pressure reducer; and a temperature sensor 2 which is composed of a thermistor and which detects the temperature of the evaporator 1. The vehicular air-conditioning apparatus controls the temperature of the evaporator 1 by means of turning the compressor on and off on the basis of the temperature detected by the temperature sensor 2.

[0025] As shown in FIGS. 1 through 3, the evaporator 1 includes a leeward tube row 4 and a windward tube row 5. Each of the leeward tube row 4 and the windward tube row 5 includes a plurality of flat heat exchange tubes 3 made of aluminum and disposed at predetermined intervals in a left-right direction (a direction orthogonal to an air-passing direction indicated by the arrow X in FIG. 1) in such a manner that their width directions coincide with the air-passing direction and their longitudinal directions coincide with the vertical direction. A leeward upper header section 6 and a leeward lower header section 7 which are made of aluminum are disposed at the upper and lower ends, respectively, of the heat exchange tubes 3 of the leeward tube row 4 in such a manner that their longitudinal directions coincide with the left-right direction (the direction in which the heat exchange tubes 3 are juxtaposed). All the heat exchange tubes 3 of the leeward tube row 4 are connected to the leeward upper header section 6 and the leeward lower header section 7. A windward upper header section 8 and a windward lower header section 9 which are made of aluminum are disposed at the upper and lower ends, respectively, of the heat exchange tubes 3 of the windward tube row 5 in such a manner that their longitudinal directions coincide with the left-right direction (the direction in which the heat exchange tubes 3 are juxtaposed). All the heat exchange tubes 3 of the windward tube row 5 are connected to the windward upper header section 8 and the windward lower header section 9. The number of the heat exchange tubes 3 of the leeward tube row 4 is equal to the number of the heat exchange tubes 3 of the windward tube row 5.

[0026] The evaporator 1 includes a plurality of corrugated fins 12 made of aluminum. Each corrugated fin 12 is disposed to extend over an air-passing gap 11 between adjacent heat exchange tubes 3 of the leeward tube row 4 and an air-passing gap 11 between corresponding adjacent heat exchange tubes 3 of the windward tube row 5 such that the fin 12 is shared by the corresponding heat exchange tubes 3 of the two tube rows 4 and 5. Each corrugated fin 12 is brazed to the corresponding heat exchange tubes 3. Also, the corrugated fins 12 are disposed outward of the heat exchange tubes 3 at the left and right ends such that the fins 12 are shared by the corresponding heat exchange tubes 3 of the two tube rows 4 and 5, and are brazed to these heat exchange tubes 3. A side plate 13 made of aluminum is disposed on the outer side of each of the corrugated fins 12 at the left and right ends, and is brazed to the corresponding corrugated fin 12. Each corrugated fin 12 has crest portions, trough portions, and connection portions connecting the crest portions and the trough portions. The gaps between the heat exchange tubes 3 at the left and right ends and the corresponding side plates 13 also serve as air-passing gaps 11. Air having passed through the air-passing gaps 11 each located between adjacent heat exchange tubes 3 of the two tube rows 4 and 5 is fed into the cabin of the vehicle on which the vehicular air-conditioning apparatus is mounted.

[0027] As shown in FIGS. 2 through 4, the leeward tube row 4 includes an odd number (at least three) of tube groups (in the present embodiment, first through third tube groups 14, 15, and 16) each composed of a plurality of continuously juxtaposed heat exchange tubes 3, and the windward tube row 5 includes tube groups (in the present embodiment, fourth and fifth tube groups 17 and 18) the number of which is one less than the number of the tube groups 14, 15, and 16 of the leeward tube row 4 and each of which is composed of a plurality of continuously juxtaposed heat exchange tubes 3.

[0028] The temperature sensor 2, which is composed of, for example, a thermistor, is attached to adjacent connection portions of a certain corrugated fin 12 disposed in a certain air-passing gap 11 of the third tube group 16 such that the temperature sensor 2 is located between the adjacent connection portions. The temperature sensor 2 detects the temperature of the corrugated fins 12 disposed in the third tube group 16 of the evaporator 1. When the temperature detected by the temperature sensor 2 becomes equal to or lower than an off-side target temperature, the clutch means is brought into a disconnected or disengaged state, whereby the compressor is stopped. When the temperature detected by the temperature sensor 2 elevates to an on-side target temperature higher than the off-side target temperature by a predetermined temperature, the clutch means is brought into a connected or engaged state, whereby operation of the compressor is resumed.

[0029] In the leeward tube row 4, the first tube group 14 is located at the right end, the second tube group 15 is located at the center in the left-right direction, and the third tube group 16 is located at the left end. In the windward tube row 5, the fourth tube group 17 is located on the left side, and the fifth tube group 18 is located on the right side. The number of the heat exchange tubes 3 constituting the second tube group 15 is equal to or greater than the number of the heat exchange tubes 3 constituting the first tube group 14, and the total number of the heat exchange tubes 3 of the two tube groups 14 and 15 is equal to the number of the heat exchange tubes 3 constituting the fifth tube group 18. The number of the heat exchange tubes 3 constituting the third tube group 16 and the number of the heat exchange tubes 3 constituting the fourth tube group 17.
tube group 17 are equal to each other. As a result, the total width of the first and second tube groups 14 and 15 as measured in the left-right direction is the same as the width of the fifth tube group 18 as measured in the left-right direction, and the width of the third tube group 16 as measured in the left-right direction is the same as the width of the fourth tube group 17 as measured in the left-right direction. The first tube group 14 of the leeward tube row 4 located at the right end forms a first path through which the refrigerant first flows, and the fifth tube group 18 of the windward tube row 5 located on the right side forms a last path through which the refrigerant flows last.

0030 The leeward upper header section 6 and the windward upper header section 8 are provided by, for example, dividing the interior of a single tank 19 into two spaces in the air-passing direction by a partition 19a extending in the left-right direction. Similarly, the leeward lower header section 7 and the windward lower header section 9 are provided by, for example, dividing the interior of a single tank 21 into two spaces in the air-passing direction by a partition 21a extending in the left-right direction.

0031 The interior of the leeward upper header section 6 is divided by a partition 6a into a plurality of spaces arranged in the left-right direction. Thus, a first section 22 with which the heat exchange tubes 3 of the first tube group 14 communicate and a second section 23 with which the heat exchange tubes 3 of the second and third tube groups 15 and 16 communicate are provided in the leeward upper header section 6. A refrigerant inlet 24 is provided at the right end of the first section 22.

0032 The interior of the leeward lower header section 7 is divided by a partition 7a into a plurality of spaces arranged in the left-right direction. Thus, a third section 25 with which the heat exchange tubes 3 of the first and second tube groups 14 and 15 communicate and a fourth section 26 with which the heat exchange tubes 3 of the third tube group 16 communicate are provided in the leeward lower header section 7.

0033 The interior of the windward upper header section 8 is divided by a partition 8a into a plurality of spaces arranged in the left-right direction. Thus, a fifth section 27 with which the heat exchange tubes 3 of the fourth tube group 17 communicate and a sixth section 28 with which the heat exchange tubes 3 of the fifth tube group 18 communicate are provided in the windward upper header section 8. A refrigerant outlet 29 is provided at the right end of the sixth section 28.

0034 The windward lower header section 9 includes a seventh section 32 with which the heat exchange tubes 3 of the fourth tube group 17 and the fifth tube group 18 communicate and which extends over the entirety of the windward lower header section 9.

0035 Communication is established, thorough a communication opening 33 provided in the partition 19a between the fifth section 27 of the windward upper header section 8 and a portion of the second section 23 of the leeward upper header section 6, with which portion the heat exchange tubes 3 of the third tube group 16 communicate. Also, communication is established, thorough a plurality of communication openings 34 provided in the partition 21a between the fourth section 26 of the leeward lower header section 7 and a portion of the seventh section 32 of the windward lower header section 9, with which portion the heat exchange tubes 3 of the fourth tube group 17 communicate.

0036 The first through fifth tube groups 14, 15, 16, 17, and 18 are provided in the leeward tube row 4 and the windward tube row 5 as described above. Also, the refrigerant inlet 24, the refrigerant outlet 29, the first through seventh sections 22, 23, 25, 26, 27, 28, and 32, and the communication openings 33 and 34 are provided in the two leeward header sections 6 and 7 and the two windward header sections 8 and 9 as described above. As a result, the refrigerant flows from the upper side toward the lower side within the heat exchange tubes 3 of the first tube group 14, the third tube group 16, and the fourth tube group 17, and the refrigerant flows from the lower side toward the upper side within the heat exchange tubes 3 of the second tube group 15 and the fifth tube group 18. Each of the first tube group 14, the second tube group 15, and the fifth tube group 18 forms a single heat exchange path, and the third and fourth (two) tube groups 16 and 17 form a single heat exchange path.

0037 Accordingly, as shown in FIG. 4, the refrigerant whose pressure has been reduced by the pressure reducer flows into the first section 22 through the refrigerant inlet 24, flows along two routes as follows, and flows out from the refrigerant outlet 29 of the sixth section 28 toward the compressor. The first route extends through the first section 22, the first tube group 14, the third section 25, the second tube group 15, the second section 23, the fourth tube group 16, the fourth section 26, the communication openings 34, the seventh section 32, the fifth tube group 18, and the sixth section 28. The second route extends through the first section 22, the first tube group 14, the third section 25, the second tube group 15, the second section 23, the communication opening 33, the fifth section 27, the fourth tube group 17, the seventh section 32, the fifth tube group 18, and the sixth section 28. The first tube group 14 forms a first path, the second tube group 15 forms a second path, the third and fourth tube groups 16 and 17 form a third path, and the eighth tube group 18 forms a fourth path.

0038 In the above-described vehicular air-conditioning apparatus, the gas-liquid mixed phase refrigerant having passed through the compressor, the condenser, and the expansion valve passes through the refrigerant inlet 24, and enters the first section 22 of the leeward upper header section 6. The refrigerant then flows along the above-described two routes, and flows out from the refrigerant outlet 29 of the sixth section 28 toward the compressor. While flowing through the heat exchange tubes 3 of the leeward tube row 4 and the heat exchange tubes 3 of the windward tube row 5, the refrigerant exchanges heat with air passing through the air-passing gaps 11 (see the arrow X in FIGS. 1 and 4). As a result, the air is cooled, and the refrigerant flows out in gaseous phase.

0039 When the temperature of the corrugated fins 12 disposed in the third tube group 16 of the evaporator 1 detected by the temperature sensor 2 becomes equal to or lower than the off-side target temperature, the clutch means is brought into a disconnected or disengaged state, whereby the compressor is stopped. When the temperature of the corrugated fins 12 disposed in the third tube group 16 of the evaporator 1 detected by the temperature sensor 2 elevates to the on-side target temperature higher than the off-side target temperature by a predetermined temperature, the clutch means is brought into a connected or engaged state, whereby operation of the compressor is resumed.

0040 The refrigerant having flowed into the evaporator 1 through the refrigerant inlet 24 thereof flows over substantially the same period of time and the same distance before reaching the third tube group 16, which is the farthest tube group of the leeward tube row 4, and before reaching the fourth tube group 17, which is the farthest tube group of the windward tube row 5. Therefore, when the compressor is
switched from the off state to the on state, the heat exchange tubes 3 and the corrugated fins 12 disposed in the two tube groups 16 and 17 of the evaporator 1 are cooled uniformly. As a result, when the compressor is turned on, the temperature of the corrugated fins 12 disposed in the third tube group 16 of the evaporator 1 becomes equal to or lower than the off-side target temperature within a relatively short period of time. Accordingly, it is possible to prevent occurrence of a problem in that the temperatures of the heat exchange tubes 3 and the corrugated fins 12 disposed in the tube groups of the evaporator 1 other than the third tube group 16 and the fourth tube group 17 (i.e., the first tube group 14, the second tube group 15, and the fifth tube group 18) decrease, and condensed water freezes on the surfaces of the heat exchange tubes 3 and the corrugated fins 12. As a result, production of an offensive smell called freezing odor, which is produced as a result of freezing of condensed water, can be restrained.

[0041] Also, when the compressor is switched from the off state to the on state, the temperature of a portion of the evaporator 1 where the first tube group 14 of the leeward tube row 4 closest to the refrigerant inlet 24 is present is apt to decrease sharply. However, the decrease in the temperature of the portion of the evaporator 1 where the first tube group 14 is present, which decreases occurs when the compressor is switched from the off state to the on state, is mitigated for the following reason. When the compressor is off, due to presence of a super heat region in the fifth tube group 18 of the windward tube row 5 closest to the refrigerant outlet 29, the temperature of a portion of the evaporator 1 where the fifth tube group 18 is present becomes considerably high. This high temperature mitigates the above-mentioned decrease in the temperature of the portion of the evaporator 1 where the first tube group 14 is present. Accordingly, when the compressor is on, the decrease in the temperature of the portion of the evaporator 1 where the first tube group 14 of the leeward tube row 4 is present is restrained, whereby freezing of condensed water is restrained.

[0042] In the above-described embodiment, three tube groups are provided in the leeward tube row 4, and two tube groups are provided in the windward tube row 5. However, the present invention is not limited thereto. Also, depending on the number of tube groups of the two tube rows 4 and 5, there may be employed a structure in which the refrigerant inlet is provided at the leeward lower header section, and the refrigerant outlet is provided at the windward lower header section.

[0043] Notably, the present invention can be applied to a so-called laminated-type evaporator in which a plurality of flat hollow bodies each composed of a pair of dish-shaped plates which faces each other and are brazed together along the circumferential edges thereof are disposed in parallel. Each flat hollow body has two heat exchange tubes juxtaposed in the air-passing direction and forming the heat exchange tubes, and upper and lower header forming portions communicating with the upper and lower ends of the two heat exchange tubes. All the flat hollow bodies are brazed together in such a manner that the upper header forming portions of all the flat hollow bodies communicate with one another, and the lower header forming portions of all the flat hollow bodies communicate with one another. Thus, two tube rows each composed of a plurality of heat exchange tubes extending in the vertical direction and disposed at predetermined intervals in a direction orthogonal to the air-passing direction are juxtaposed in the air-passing direction, and the upper and lower header sections on the leeward and windward sides with which the upper and lower ends of the leeward and windward tube rows communicate are provided by the header forming portions of all the flat hollow bodies.

What is claimed is:

1. An air-conditioning apparatus for a vehicle comprising a compressor which uses an engine as a drive source and is connected to the engine through clutch means; a condenser for cooling refrigerant compressed by the compressor; a pressure reducer for reducing the pressure of the refrigerant cooled by the condenser; an evaporator for evaporating the refrigerant whose pressure has been reduced by the pressure reducer; and a temperature sensor for detecting the temperature of the evaporator, the air-conditioning apparatus controlling the temperature of the evaporator by turning the compressor on and off on the basis of the temperature detected by the temperature sensor, wherein

the evaporator includes leeward and windward tube rows which are juxtaposed in an air-passing direction and each of which is composed of a plurality of heat exchange tubes disposed at predetermined intervals in a direction orthogonal to the air-passing direction such that their longitudinal directions coincide with a vertical direction;

the leeward tube row includes three or more tube groups each composed of a plurality of heat exchange tubes, and the windward tube row includes tube groups the number of which is one less than the number of the tube groups of the leeward tube row and each of which is composed of a plurality of heat exchange tubes;

upper and lower ends of the heat exchange tubes of the leeward tube row communicate with leeward upper and lower header sections, respectively, and upper and lower ends of the heat exchange tubes of the windward tube row communicate with windward upper and lower header sections, respectively;

a refrigerant inlet is provided at one end of one leeward header section selected from the leeward upper and lower header sections, and a refrigerant outlet is provided at one end of one windward header section selected from the windward upper and lower header sections in such a manner that the refrigerant outlet and inlet are located side by side in the air-passing direction.

a flow direction of refrigerant within the heat exchange tubes of a farthest tube group of the leeward tube row located at a position farthest from the refrigerant inlet is the same as a flow direction of refrigerant within the heat exchange tubes of a farthest tube group of the windward tube row located at a position farthest from the refrigerant outlet;

a single path is formed by the two farthest tube groups which are juxtaposed in the air-passing direction and which are the same in the flow direction of refrigerant within the heat exchange tubes; and

a single temperature sensor is disposed on the evaporator so as to detect the temperature of a portion of the evaporator where the farthest tube group of the leeward tube row is provided.

2. An air-conditioning apparatus for a vehicle according to claim 1, wherein the temperature sensor is composed of a thermistor, and is attached to a fin disposed between adjacent heat exchange tubes of the farthest tube group of the leeward tube row.
3. An air-conditioning apparatus for a vehicle according to claim 1, wherein
first through third tube groups each composed of a plurality of heat exchange tubes are provided in the leeward tube row of the evaporator in such a manner that the first through third tube groups are arranged in this order from one end of the leeward tube row on the refrigerant inlet side toward the other end of the leeward tube row; fourth and fifth tube groups each composed of a plurality of heat exchange tubes are provided in the windward tube row of the evaporator in such a manner that the fourth and fifth tube groups are arranged in this order from one end of the windward tube row opposite the refrigerant outlet toward the other end of the windward tube row located on the refrigerant outlet side; a predetermined number of sections are provided in each of the leeward upper and lower header sections and the windward upper and lower header sections, whereby the first tube group serves as a first path where the refrigerant flows within the heat exchange tubes from one of upper and lower sides where the refrigerant inlet is located to the opposite side, the second tube group serves as a second path where the refrigerant flows within the heat exchange tubes in a direction opposite the flow direction in the first path, the third and fourth tube groups serve as a third path where the refrigerant flows within the heat exchange tubes in the same direction as the flow direction in the first path, and the fifth tube group serves as a fourth path where the refrigerant flows within the heat exchange tubes in the direction opposite the flow direction in the first path; and the third and fourth tube groups which are the same in the flow direction of the refrigerant within the heat exchange tubes are juxtaposed in the air-passing direction.

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