AIR CONDITIONER FOR DOUBLE-DECK-BUS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an air conditioner for a vehicle, having plural passenger compartments, such as a double-deck-bus (double-decker).

2. Description of Related Art:

In a present air conditioner for a double-deck-bus having a first floor compartment and a second floor compartment, because solar radiation is greatly introduced into the second floor compartment and the temperature of the second floor compartment readily increases, two evaporators are disposed for cooling air blown into the second floor compartment while one evaporator is disposed for cooling air blown into the first floor compartment. However, in a-bdouble-deck-bus on a regular route, because passengers frequently get on and off the first floor compartment, cooling capacity may be insufficient in the first floor compartment when only the one evaporator is disposed for cooling the first floor compartment. Accordingly, in this air conditioner, it is difficult to provide cooling capacity corresponding to a change of cooling load in each compartment.

SUMMARY OF THE INVENTION

In view of the foregoing problems, it is an object of the present invention to provide an air conditioner for a

vehicle having plural compartments, which can obtain cooling capacity corresponding to a change of cooling load in each compartment.

According to the present invention, in an air conditioner for a vehicle having a first compartment and a second compartment, a first cooling unit is disposed for cooling air blown into the first compartment, a second cooling unit is disposed for cooling air blown into the second compartment, and a third cooling unit is disposed for cooling air blown into both the first compartment and the second compartment. Accordingly, when the cooling capacity in the first compartment is insufficient, air cooled in the third evaporator is supplied into the first compartment so that the insufficient cooling capacity in the first compartment is supplemented. On the other hand, when the cooling capacity in the second compartment is insufficient, air cooled in the third evaporator is supplied into the second compartment so that the insufficient cooling capacity in the second compartment is supplemented. Because cooling capacity corresponding to a change of the cooling load in each compartment can be obtained, it can prevent the compartments from being excessively cooled while a suitable cooling balance can be maintained between the first compartment and the second compartment. Thus, when the air conditioner is used for a double-deck-bus, first and second floor compartments can be suitably cooled in accordance with cooling load in each of the first and second floor compartments.

Preferably, the first cooling unit is operated in accordance with the cooling load in the first compartment, the second cooling unit is operated in accordance with the cooling load in the second compartment, and the third cooling unit is operated in accordance with cooling loads in both of the first and second compartments. In addition, an air-blowing amount of a first blower for blowing air into the first compartment is changed in accordance with the cooling load in the first compartment, and an air-blowing amount of a second blower for blowing air into the second compartment is changed in accordance with the cooling load in the second compartment. Accordingly, each of the first and second compartments can be suitably cooled in accordance with the cooling load.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects and advantages of the present invention will be more readily apparent from the following detailed description of preferred embodiment when taken together with the accompanying drawings, in which:

FIG. 1 is a perspective view showing a double-deck-bus on which an air-conditioning unit of an air conditioner according to a first preferred embodiment of the present invention is mounted;

FIG. 2 is a perspective view of a bus rear portion having the air-conditioning unit, according to the first embodiment;

FIG. 3 is a schematic sectional view showing the air-

conditioning unit according to the first embodiment;

FIG. 4 is a schematic diagram showing a vapor-compression refrigerant cycle system according to the first embodiment;

FIG. 5 is a cross-sectional view taken along line V-V in FIG. 3;

FIG. 6 is a cross-sectional view taken along line VI-VI in FIG. 3;

FIGS. 7A-7F are diagrams showing control operation of an air conditioner for a double-deck-bus, according to a second preferred embodiment of the present invention; and

FIGS. 8A and 8B are diagrams showing control operation of the air conditioner according to the second embodiment.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described hereinafter with reference to the accompanying drawings.

A first preferred embodiment of the present invention will be now described with reference to FIGS. 1-6. In the first embodiment, the present invention is typically applied to a double-deck-bus (double-decker) having a first floor compartment and a second floor compartment. FIG. 1 shows the double-deck-bus on which an arrangement position of an air-conditioning unit 1 of an air conditioner is disposed. Generally, the air-conditioning unit 1 is disposed in a bulkhead portion 31 at a most rear side of the double-deck-

bus, as shown in FIG. 2. Two second-floor air ducts 2, for introducing conditioned air from the air-conditioning unit 1 toward a ceiling portion of the second floor compartment, are disposed, to extend vertically from the air-conditioning unit 1 to the ceiling portion at right and left both sides and to extend on the ceiling portion in a front-rear direction at both the right and left sides.

A first-floor air duct 3, for introducing conditioned air from the air-conditioning unit 1 toward a ceiling portion of the first floor compartment, is disposed at an approximate center portion in the ceiling portion of the first floor compartment, to extend long in the front-rear direction. Plural air outlets for blowing conditioned air toward passengers are provided in each of the air ducts 2, 3.

An outside air introduction port 4 for introducing outside air outside the compartments is provided in a side surface of the double-deck-bus as shown in FIGS. 1 and 2, for cooling condensers described later. Plural air discharge ports 5, for discharging air after cooling the condensers, are provided at a rear side in the double-deck-bus as shown in FIG. 1. A blower unit 6 for blowing outside air toward the condensers is constructed by plural axial fans (e.g., six fans in the first embodiment) arranged in a width direction (right-left direction). The plural air discharge ports 5 are arranged in width direction on a rear surface of the double-deck-bus to be opposite to the plural axial fans of the blower unit 6.

As shown in FIG. 2, the air-conditioning unit 1 includes an air-conditioning case 10 defining an outer periphery of the air-conditioning unit 1. The air-conditioning case 10 is formed into an approximate rectangular parallelopiped shape elongated in the width direction, by a metal plate such as an iron plate. As shown in FIG. 3, the air-conditioning case 10 is partitioned into upper and lower two parts in an up-down direction to be heat-insulated. A cooling unit 11 for cooling air blown into the compartments is disposed in the upper part of the air-conditioning case 10, and a condensing unit 12 for discharging heat of the compartments to an exterior is disposed in the lower part of the air-conditioning case 10.

Air outlets 24 are provided in the air-conditioning case 10 so that conditioned air is introduced into the air ducts 2 through the air outlets 24. Further, an air outlet 28 is provided in the air-conditioning case 10 so that conditioned air is introduced into the air duct 3 through the air outlet 28. In FIG. 2, reference number 30 indicates passenger seats provided in the first floor compartment.

Three evaporators 13a-13c (13) each of which extends over in the width direction are disposed at a front side in the cooling unit 11. Specifically, the evaporator 13a at the lower side is a first air cooler for cooling air blown into the first floor compartment through the first floor air duct 3. The evaporator 13b at the upper side is a second air cooler for cooling air blown into the second floor compartment

through the second floor air ducts 2. Further, the evaporator 13c between both the evaporators 13a, 13b is a third air cooler for cooling air blown into the first floor compartment and for cooling air blown into the second floor compartment.

As shown in FIG. 4, the three evaporators 13a-13c are connected to first through third compressors Cp1-Cp3 in first through third refrigerant cycles, respectively, so that refrigerant flows into the three evaporators 13a-13c by the operation of the first through third compressors Cp1-Cp3, respectively. The first through third compressors Cp1-Cp3 are driven by an engine (not shown), for example.

Each of the evaporators 13a-13c is a low-pressure side heat exchanger in a vapor-compression refrigerant cycle. In each of the evaporators 13a-13c, cooling capacity for cooling air can be obtained by evaporating refrigerant. Because the three compressors Cp1-Cp3 are provided relative to the three evaporators 13a-13c, three refrigerant cycles can be constructed. In the refrigerant cycle system, three condensers Cn1-Cn3 for condensing refrigerant from the compressors Cp1-Cp3, respectively, are provided. Refrigerant from the condensers Cn1-Cn3 flows into three receivers Re1-Re3, respectively, to be separated into gas refrigerant and liquid refrigerant. Liquid refrigerant flowing from the receivers Re1-Re3 is super-cooled in three super-cooling units Sc1-Sc3, respectively, and flows into three drying units Dr1-Dr3, respectively, for removing water contained in refrigerant. Three expansion valves Ex1-Ex3 are disposed for

decompressing refrigerant from the three drying units Dr1-Dr3, respectively.

Cabin air temperature sensors S1 are disposed for detecting temperature of cabin air cabin the compartments, sucked into the cooling unit 11. Evaporator temperature sensors S2 are disposed for detecting temperature of air immediately after passing through the evaporators 13a-13c. In the first embodiment, the three condensers Cn1-Cn3 are integrated as a single condenser 29, and the integrated condenser 29 is disposed in the condensing unit 12, as shown in FIG. 3. Further, an outside air temperature sensor (TAM sensor), for detecting temperature of outside air blown toward the three condensers Cn1-Cn3, are disposed.

In FIG. 4, each low-pressure SW indicates a sensor for detecting the pressure or the temperature of low-pressure side refrigerant in each refrigerant cycle, each middle-pressure SW indicates a sensor for detecting the pressure or the temperature of middle-pressure side refrigerant in each refrigerant cycle, and each high-pressure SW indicates a sensor for detecting the temperature or the pressure of high-pressure side refrigerant in each refrigerant cycle. In this embodiment, the refrigerant cycle system is constructed by the three refrigerant cycles.

As shown in FIG. 2, two first cabin air suction ports 14 enlarged vertically are provided at right and left sides on an end surface of the cooling unit 11, adjacent to the passenger compartments. The first floor air duct 3 is

disposed between the two first cabin air suction ports 14 at an approximate center position of the cooling unit 11 in the width direction. On the other hand, a second cabin air suction port 15 is provided above the first floor air duct 3. Accordingly, cabin air introduced from the first and second cabin air suction ports 14, 15 flows into the evaporator 13 to be cooled by the evaporator 13.

As shown in FIG. 3, upper and lower wall plates 16a, 16b extending in the up-down direction are disposed opposite to the evaporator 13 at a downstream air side of the evaporator 13 to have a predetermined distance between the evaporator 13 and the wall plates 16a, 16b in the front-rear direction. Each of the wall plates 16a, 16b is formed by a metal plate such as an iron plate.

A partition plate 17 extending in a horizontal direction is disposed within the air-conditioning case 10 to partition a downstream passage of the evaporator 13 into an upper side passage 18 and a lower side passage 19. The upper wall plate 16a is disposed to cross the upper side passage 18, and the lower wall plate 16b is disposed to cross the lower side passage 19. Therefore, an upper air chamber 20 is defined in the upper side passage 18 by the upper wall plate 16a, and a lower air chamber 21 is defined in the lower side passage 19 by the lower wall plate 16b.

As shown in FIG. 5, the upper wall plate 16a placed in the upper side passage 18 is formed stepwise so that a center portion of the upper wall plate 16a in the width direction is

most separated from the evaporator 13. Plural blowers 22 (e.g., six fans) are disposed in the upper wall plate 16a. On the other hand, as shown in FIG. 6, the lower wall plate 16b positioned in the lower side passage 19 is formed to extend linearly in the width direction, and plural blowers 25 (e.g., six fans) are disposed in the lower wall plate 16b.

Further, as shown in FIG. 3, plural air suction ports 23 (e.g., six ports) from which cabin air is sucked into the blowers 22 are provided in the upper wall plate 16a. Similarly, as shown in FIG. 3, plural air suction ports 26 (e.g., six ports) from which cabin air is sucked into the blowers 25 are provided in the lower wall plate 16b.

Next, operation of the air conditioner for the double-deck-bus according to the first embodiment of the present invention will be now described.

When a first mode is set, the first floor compartment is cooled by the maximum cooling capacity. In the first mode, the first compressor Cp1, the third compressor Cp3 and the blowers 25 are operated, so that air cooled by the first evaporator 13a and the third evaporator 13c is supplied into the first floor compartment. Therefore, in the first mode, the first floor compartment can be cooled by the maximum cooling capacity.

When a second mode is set, the first floor compartment is cooled with a cooling capacity smaller than that in the first mode. In the second mode, the first compressor Cp1 and the blowers 25 are operated, so that air blown into the first

floor compartment is cooled by the first evaporator 13a. In the second mode, the first compressor Cp1 and the third compressor Cp3 can be alternately operated.

When a third mode is set, the first compressor Cp1 and the blowers 25 are stopped, so that the cooling operation in the first floor compartment is stopped.

When a fourth mode is set, the second floor compartment is cooled by the maximum cooling capacity. In the fourth mode, the second compressor Cp2, the third compressor Cp3 and the blowers 22 are operated so that air cooled by the second evaporator 13b and the third evaporator 13c is supplied into the second floor compartment. Accordingly, in the fourth mode, the second floor compartment is cooled by the maximum cooling capacity.

When a fifth mode is set, the second floor compartment is cooled by a cooling capacity smaller than that in the fourth mode. In the fifth mode, the second compressor Cp1 and the blowers 22 are operated so that second floor compartment is cooled by the second evaporator 13b. In the fifth mode, the second compressor Cp2 and the third compressor Cp3 can be alternately operated.

When a sixth mode is set, the second compressor Cp2 and the blowers 25 are stopped so that the cooling operation of the second floor compartment is stopped.

According to the first embodiment of the present invention, the first evaporator 13a is operated only for the first floor compartment, the second evaporator 13b is operated

only for the second floor compartment, and the third evaporator 13c is operated for both the first and second floor compartments. Accordingly, when the cooling capacity in the first floor compartment is insufficient, air cooled by the third evaporator 13c is also supplied to the first floor compartment to supplement the cooling capacity in the first floor compartment. On the other hand, when the cooling capacity in the second floor compartment is insufficient, air cooled by the third evaporator 13c is supplied to the second floor compartment to supplement the cooling capacity in the second floor compartment. Thus, cooling capacity corresponding to a change of cooling load in each compartment can be obtained. As a result, it can prevent the compartments from being excessively cooled while a balance of cooling capacity between the first floor compartment and the second floor compartment can be suitably maintained.

A second preferred embodiment of the present invention will be now described with reference to FIGS. 7A-7F and 8A-8B. In the second embodiment, the structure of the air conditioner is similar to that of the above-described first embodiment. In the second embodiment, the control operations of the compressors Cp1-Cp3 and the blowers 22, 25 are set as shown in FIGS. 7A-7F and in FIGS. 8A and 8B. In FIGS. 7A-7F and FIGS. 8A and 8B, "○" indicates that the compressor Cp1-Cp3 is operated, "×" indicates that the compressor Cp1-Cp3 is stopped. Further, in the air-blowing amount of the blower 22, 25, "Hi" indicates that the air-blowing amount is largest.

The air-blowing amount of the blower 22, 25 becomes smaller in this order of "Me2", "Me1", "Lo". Further, "2M1" indicates a second-floor air-conditioning mode M1, "1M1" indicates a first-floor air-conditioning mode M1, "2M2" indicates a second-floor air-conditioning mode M2, "1M2" indicates a first-floor air-conditioning mode M2. In addition, the cooling capacity of M1 becomes maximum, and the cooling capacity is gradually reduced in this order of M2, M3, M4 and M5. In the second embodiment, because five air-conditioning modes M1-M5 are set for the first floor compartment and five air-conditioning modes M1-M5 are set for the second floor compartment, the air conditioner of the second embodiment has 25 operation modes (5×5), as shown in FIGS. 7A-7F.

As shown in FIG. 7A, when both the first and second floor compartments need the maximum cooling capacity (2M1, 1M1), all the compressors Cp1-Cp3 are operated, and the blowers 22, 25 are operated by the air-blowing amount (blower voltage) of "Hi". On the other hand, when the cooling operation is nearly unnecessary in both the first and second floor compartments (2M5, 1M5), all the compressors Cp1-Cp3 are stopped, and the blowers 22, 25 are operated by the air-blowing amount (blower voltage) of Lo. In this case, the blowers 22, 25 may be stopped. The other air-conditioning modes are shown in FIGS. 7A-7F, and detail explanation thereof is omitted.

FIGS. 8A and 8B show independent controls of the first-floor air-conditioning mode and the second-floor air-

conditioning mode. That is, the common third compressor Cp3 is operated for one of the first floor compartment and the second floor compartment in one operation mode. Therefore, one of the first floor compartment and the second floor compartment can be cooled preferentially with a large cooling capacity by the operation of the third compressor Cp3. Accordingly, as shown in FIGS, 8A and 8B, when the first-floor air-conditioning mode and the second-floor air-conditioning mode are simply combined, combination operation modes of 2M1 and 1M3, 2M1 and 1M4, 2M1 and 1M5, 2M2 and 1M3, 2M2 and 1M4, 2M2 and 1M5, 2M3 and 1M1, 2M3 and 1M2, 2M4 and 1M1, 2M4 and 1M2, 2M5 and 1M1, and 2M5 and 1M2 can be obtained.

Accordingly, the evaporators 13a-13b can be effectively operated in accordance with a change of cooling load in each of the first and second floor compartments.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications will become apparent to those skilled in the art.

For example, in the above-described embodiments, the present invention is typically applied to the double-deck-bus (double-decker). However, the present invention can be applied to the other vehicle having plural compartments.

In the above-described embodiments of the present invention, the number of the compressors Cp1-Cp3 is set equal to the number of the evaporators 13a-13c. However, the number

of the compressors can be set smaller than that of the evaporators 13a-13c. Further, by using a single compressor, refrigerant can be supplied to plural evaporators for cooling air blown into the plural compartments.

Such changes and modifications are to be understood as being within the scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. An air conditioner for a vehicle having a first compartment and a second compartment, the air conditioner comprising:

a first cooling unit (13a) for cooling air blown into the first compartment;

a second cooling unit (13b) for cooling air blown into the second compartment; and

a third cooling unit (13c) for cooling air blown into both the first compartment and the second compartment.

2. The air conditioner according to claim 1, further comprising:

a first blower (25) for blowing air into the first compartment; and

a second blower (22) for blowing air into the second compartment.

3. The air conditioner according to claim 1, wherein:

each of the first through third cooling units (13a, 13b, 13c) is an evaporator in a refrigerant cycle; and

the evaporator is disposed to cool air passing therethrough by evaporating refrigerant.

4. The air conditioner according to claim 3, further comprising:

a first compressor (Cp1) for compressing refrigerant

and for circulating refrigerant into the first cooling unit (13a);

a second compressor (Cp2) for compressing refrigerant and for circulating refrigerant into the second cooling unit (13b); and

a third compressor (Cp3) for compressing refrigerant and for circulating refrigerant into the third cooling unit (13c).

5. The air conditioner according to claim 4, further comprising:

a first blower (25) for blowing air into the first compartment; and

a second blower (22) for blowing air into the second compartment, wherein:

in a first maximum cooling mode for cooling the first compartment by maximum cooling capacity, the first compressor (Cp1), the third compressor (Cp3) and the first blower (25) are operated; and

in a second maximum cooling mode for cooling the second compartment by maximum cooling capacity, the second compressor (Cp2), the third compressor (Cp3) and the second blower (22) are operated.

6. The air conditioner according to claim 2, wherein:

an air-blowing amount of the first blower (25) is changed in accordance with a cooling load in the first

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compartment; and

an air-blowing amount of the second blower (22) is changed in accordance with a cooling load in the second compartment.

7. The air conditioner according to claim 1, wherein:

the first cooling unit (13a) is operated in accordance with the cooling load in the first compartment;

the second cooling unit (13b) is operated in accordance with the cooling load in the second compartment; and

the third cooling unit (13c) is operated in accordance with cooling loads in the first and second compartments.

8. The air conditioner according to any one of claims 1-7, wherein the second compartment is positioned above the first compartment.

9. An air conditioner for a double-deck-bus having a first floor compartment and a second floor compartment, the air conditioner comprising:

a first cooling unit (13a) for cooling air blown into the first floor compartment;

a second cooling unit (13b) for cooling air blown into the second floor compartment; and

a third cooling unit (13c) for cooling air blown into both the first floor compartment and the second floor

compartment.

10. The air conditioner according to claim 9, further comprising:

a first blower (25) for blowing air into the first floor compartment; and

a second blower (22) for blowing air into the second floor compartment.

