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(54) **Railway car comprising air intake device, evacuation device and evacuation air fan, and method for controlling such devices**

Eisenbahnwaggon, der eine Luftansaugvorrichtung, eine Absaugvorrichtung und einen Absaugventilator umfasst, und Verfahren zur Steuerung solcher Vorrichtungen

Wagon de chemin de fer comprenant un dispositif d'entrée d'air, dispositif d'évacuation et ventilateur d'air à évacuation et procédé pour commander ces dispositifs

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Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to a railway car capable of controlling opening rates of air intake devices for introducing outside air into the railway car and evacuation devices for evacuating the air inside the car to the exterior based for example on the inside temperature, the outside temperature and the railway car speed, based on which the operation rate of an air-conditioning unit disposed on the railway car can be reduced.

Description of the related art

[0002] Railway cars are equipped with air-conditioning units for performing cooling and heating operations for controlling the temperature and humidity inside the railway car. In railway cars running on conventional train lines for commuting and the like, one or two air-conditioning units are disposed on the rooftop at a center in the longitudinal direction of the railway car. In some limited express trains, one or two air-conditioning units are disposed under the floor in the longitudinal direction of the railway car, since better ride quality can be obtained if the center of gravity is set low when the car passes a curve at high speed.

[0003] In general, the air-conditioning unit has two openings communicated with the cabin of the railway car, and the air inside the railway car is introduced to the air-conditioning unit through one of the openings to create conditioned air by cooling or heating the air taken from the inside of the car using an indoor heat exchanger constituting a cooling cycle built into the air-conditioning unit. The conditioned air generated via the indoor heat exchanger is reflowed into the railway car through the other opening to control the temperature and humidity inside the railway car.

[0004] Since the railway car has a long, thin shape and has window glasses covering large areas thereof, the temperature inside the car varies greatly between the insulated side and the shaded side. Especially in the case of commuter trains, all the side sliding doors disposed on one side in the width direction of the railway car are opened at once when the train stops at a station, a significant amount of fresh air flows into the car. Therefore, it was difficult to accurately comprehend the inside temperature of the car which is the object of control.

[0005] A method has been proposed for accurately comprehending the inside temperature of the car by providing an outside temperature sensor disposed on the outer side of the railway car, a fresh air temperature sensor disposed at a section for introducing outside air into the car and a wall temperature sensor disposed on the surface of the inner wall of the railway car, and weighting the fresh air temperature and the wall temperature by a

weight value determined based on the outside temperature measured via the outside temperature sensor, thereby computing the current inside temperature of the car. For example, Patent document 1 (Japanese patent application laid-open publication No. 2009-90739) discloses the above-described art for specifying the temperature inside a car.

[0006] In railway cars driven via power obtained via overhead contact lines or third rails, a large portion of the power is consumed by main converters and main motors related to train operation, but in order to cut down the overall consumption power of the railway car, it is important to cut down the consumption power used for services such as air-conditioning units and illumination.

[0007] Patent document 1 discloses a method for comprehending the current temperature inside the car with high accuracy by weighting the output of temperature sensors disposed on various areas on the outer side and the inner side of the railway car based on the outside temperature. The accurate comprehension of the inside temperature of the car as target value leads to optimizing the operation rate of the air-conditioning unit, so that the consumption power of the air-conditioning unit can be cut down. However, a further problem to be solved is the reduction of consumption power consumed by the operation of the air-conditioning unit after accurately comprehending the inside temperature of the car.

EP 0700818 A1 proposes a pressure protection system for a high speed train.

SUMMARY OF THE INVENTION

[0008] The present invention aims at solving the problems of the prior art by providing a railway car capable of cutting down the consumption power of the air-conditioning unit for controlling the temperature and humidity environment inside the railway car.

[0009] The present invention provides a railway car according to claim 1.

[0010] The present invention enables to provide a railway car capable of reducing the consumption power of the air-conditioning unit for controlling the temperature and humidity environment within the railway car.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a perspective view of a railway car having an air-conditioning unit mounted on a rooftop and an outlet disposed on an end structure for evacuating the inside air to the exterior;

Fig. 2 is a perspective view showing a cross section A of the railway car shown in Fig. 1 from view B-B;

Fig. 3 is an expanded view of section C of Fig. 2, which is a vertical cross sectional view of the width direction of the railway car showing an evacuation air fan disposed on a longitudinal end of the railway

car and an opening and closing apparatus disposed on the outlet;

Fig. 4 is a perspective view of the air-conditioning unit mounted on a rooftop of the railway car, showing how the air outside the car is taken into the air-conditioning unit through an opening disposed on the side wall of the air-conditioning unit;

Fig. 5 is a perspective view showing how outside air is introduced through an air intake port disposed on an upper portion of the end structure of the railway car to a duct disposed on a ceiling of the railway car; Fig. 6 is a perspective view of an air intake device disposed on the rooftop of the railway car;

Fig. 7 is a vertical cross-sectional view of an air-conditioning unit disposed on the rooftop of the railway car in the longitudinal direction of the railway car; Fig. 8 is a cross-sectional view in a height (vertical) direction of the railway car showing a side sliding door disposed on one side structure of the railway car and a door case storing the side sliding door; Fig. 9 is a C-Cross-section of Fig. 8, showing the positional relationship in the height direction of the opening disposed on the door case and the opening and closing apparatus for evacuation disposed on the side structure;

Fig. 10 is a block diagram showing the data entered to the control unit and the object of control of the control unit;

Fig. 11 is a view showing one embodiment of the control law of the control unit shown in Fig. 10; and Fig. 12 is a timing chart showing the railway car speed and the operations of the evacuation air fan, the intake-side opening and closing apparatuses and the outlet-side opening and closing apparatuses according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A preferred embodiment of the present invention will now be described with reference to Figs. 1 through 12.

[0013] Fig. 1 is a perspective view of a railway car having an air-conditioning unit disposed on a rooftop and an outlet formed on a lower part of an end structure for evacuating the air within the car to the exterior. As shown in Fig. 1, the width direction of the railway car is denoted by number 510, and the longitudinal direction and the height direction orthogonal to the width direction are respectively denoted by numbers 520 and 530. A railway car 1 is composed of side structures 20 and 20 (only one of which is shown) erected on both ends in the width direction 510 of an underframe 10, end structures 30 and 30 (only one of which is shown) erected on both ends in the longitudinal direction 520 of the underframe 10, and a roof structure 40 disposed on an upper end in the height direction 530 of the side structures 20 and 20 and the

end structures 30 and 30.

[0014] In order to reduce weight and simultaneously improve productivity, a method has been established in which the underframe 10, the side structures 20 and the roof structure 40 are formed of hollow extruded shape members made of aluminum alloy having two opposing face plates connected together via ribs. Upon forming the underframe and various structures using hollow extruded shape members, at first, a predetermined number of extruded shape members extruded and formed into a predetermined shape are arranged side by side along a direction orthogonal to the direction of extrusion on the upper surface of a rack. Thereafter, the extruded shape members are welded via friction stir welding or fusion welding along a weld line where the weld end surfaces are butted against each other, by which the underframe and various structures formed of a single panel are formed.

[0015] Bogies 400 and 400 having multiple wheelsets supported rotatably on tracks are disposed on a lower side of the underframe 10 constituting the railway car 1 at both longitudinal ends, and the bogies 400 and 400 are connected to the underframe 10. On the lower side of the underframe 10 is disposed a control unit 16 (refer to Fig. 2) for controlling the opening rate and the operation of opening and closing apparatuses 118 (refer to Fig. 3) and an evacuation air fan 200 (refer to Fig. 3) described in detail later based on temperature sensors and humidity sensors disposed on the inner side and the outer side of the railway car 1, the boarding rate, the operating speed and position data and the like of the railway car 1.

[0016] Doors 24 enabling passengers to board and alight the railway car and windows are disposed on the side structures 20 constituting the railway car 1. As described in detail later, side sliding doors 26 (refer to Fig. 8) are disposed at the doors 24 which are capable of being opened and closed along the longitudinal direction of the railway car 1. Outlets 34 and 34 for discharging the inside air of the railway car 1 to the exterior are disposed on the end structure 30 constituting the railway car 1, and air-conditioning units 100 and 100 are disposed on the upper side of the roof structure.

[0017] Fig. 2 is a perspective view of a cross-section A of the railway car of Fig. 1 seen from view B-B. A duct 48 for blowing the conditioned air having the temperature and humidity controlled via the air-conditioning unit 100 to the longitudinal direction of the railway car 1 is disposed on the inner side of the car at the center of width of the roof structure 40 of the railway car 1. Seats 29 are disposed on the upper side of a floor 12 (underframe 10) at both width-direction ends of the railway car 1, and sliding doors 26 are disposed at the doors. An evacuation air fan chamber 36 (refer to Fig. 3) defined via a partition wall 14 is disposed at one longitudinal end of the railway car 1, and on the partition wall 14 is formed an opening 15 for guiding the air within the railway car 1 to the evacuation air fan chamber 36. Further, on the lower side of the underframe 10 is disposed a control unit 16 for con-

trolling the air-conditioning unit 100, the opening and closing apparatuses 118 for intake and outlet air and an evacuation air fan 200 (refer to Fig. 3). Fig. 2 shows an example in which the control unit 16 is disposed under the floor, but the control unit 16 can be disposed within the railway car 1, such as on the inner wall of the end structure 30 or on the inner side of the evacuation air fan chamber 36.

[0018] As described in detail later, outside air introduction devices 115 (refer to Fig. 4) are disposed on side panels 105 (refer to Fig. 4) on both width direction ends of the air-conditioning unit 100, wherein the outside air introduced into the air-conditioning unit 100 via outside air introduction ports 116 disposed on the outside air introduction devices 115 is mixed with a return air re-flow from the inside of the railway car 1 into the air-conditioning unit 100.

[0019] The outside air and inside air being mixed together is subjected to temperature and humidity control in the process of passing through a heat exchanger 112 (refer to Fig. 4) disposed on the air-conditioning unit 100, and then flown through a duct 48 disposed on a ceiling along the longitudinal direction of the railway car 1 to be supplied to various sections of the inner side of the railway car 1. The inside air corresponding to the amount of outside air being introduced to the inner side of the railway car 1 is discharged via the evacuation air fan chamber 36 (refer to Fig. 3) disposed on one longitudinal end of the railway car 1 to the exterior of the car as shown by the flow of air 500.

[0020] Fig. 3 is an expanded view of section C of Fig. 2, which shows a vertical cross-sectional view in the width direction of the railway car of an evacuation air fan 200 disposed on the upper surface of the floor 12 (underframe 10) at one longitudinal end of the railway car and an opening and closing apparatus 118 disposed on the outlet 34. An evacuation air fan chamber 36 defined via a partition wall 14 is disposed on one longitudinal end of the railway car 1. An opening 15 is formed on the partition wall 14 so as to draw the air inside the railway car 1 into the evacuation air fan chamber 36, and a temperature sensor 300 is disposed on the opening 15 for measuring the temperature of the inside air of the car. Although not shown, a humidity sensor can also be disposed with the temperature sensor 300 to measure the humidity of the air inside the car. An evacuation air fan 200 is disposed within the evacuation air fan chamber 36. The outlet of the evacuation air fan 200 is connected to the outlet 34 disposed on the lower end of the end structure 30 of the railway car 1. Slits 124 are formed on the outlet 34 to prevent dust or the like on the outside of the car from entering the evacuation air fan 200 when the evacuation air fan 200 is not operated.

[0021] An opening and closing apparatus 118 is disposed on an opening 34 arranged on the upper side of the end structure 30 within the evacuation air fan chamber 36. Blades 122 capable of pivoting around shafts 123 are disposed within the opening and closing apparatus

118, wherein the blades 122 are pivoted around the shafts 123 in response to conditions described later so as to adjust the opening rate of the opening and closing apparatus 118 and to discharge the air within the railway car 1 to the exterior. If necessary, sound absorbing materials 38 are attached to the end structure 30 and the partition wall 14 constituting the evacuation air fan chamber 36 to reduce the noise of the evacuation air fan 200.

[0022] The height H1 from the floor 12 to the outlet 34 is set to be higher than the height H2 from the floor 12 to the opening 15. Therefore, even if the noise (such as the rolling noise of wheels rolling on the rails) in the space between the end structure 30 of one railway car 1 and the end structure 30 of another railway car 1 connected thereto enters the railway car 1 via the opening and closing apparatus 118 from the outlet 34, as shown by the flow of air 500, the noise is attenuated in the process being diffracted in the height direction within the evacuation air fan chamber 36 and absorbed via the sound absorbing material 38 attached to the inner side of the evacuation air fan chamber 36, so that the transmission of noise through the opening 15 to the inside of the railway car 1 can be suppressed.

[0023] The inside air of the car within the evacuation air fan chamber 36 is discharged via an evacuation route (first evacuation flow path) in which the air is evacuated to the exterior via the opening and closing apparatus 118 using the pressure of the air within the car, and an evacuation route (second evacuation flow path) in which the air is evacuated forcibly to the exterior via the evacuation air fan 200, wherein these two evacuation routes are arranged in parallel. Therefore, under the following conditions, that is, for example, the speed of the railway car 1 is relatively high, the outside air is introduced easily into the railway car 1 and the pressure of inside air of the railway car 1 is greater than the pressure of outside air, the air inside the railway car is evacuated to the outside via the evacuation route passing the opening and closing apparatus 118. On the other hand, for example, if the speed of the railway car 1 is relatively slow and the outside air must be introduced to the inside of the railway car 1, the opening and closing apparatus 118 is closed and the evacuation air fan 200 is operated to evacuate the air inside the railway car 1 forcibly to the outside. By discharging the inside air to the outside, the pressure of air within the car becomes smaller than the outside air pressure, so that the introduction of outside air into the inner side of the car can be promoted.

[0024] Fig. 4 is a perspective view of the air-conditioning unit mounted on the rooftop of the railway car, showing a state in which the outside air is taken into the air-conditioning unit through an opening formed on the side wall of the air-conditioning unit. An upper cover disposed on the upper end of the air-conditioning unit 100 is omitted from the drawing to show the state of the flow of air 500 in the interior of the air-conditioning unit 100 disposed on the upper side of the roof structure 400. The air-conditioning unit 100 is equipped with various components

such as a compressor for compressing a gas refrigerant, a condenser for liquefying the compressed refrigerant and an outside air fan for sending air to the condenser, but these components are omitted from the drawing.

[0025] Side panels 105 and 105 erected on both ends in the width direction 510 of the air-conditioning unit 1000 are equipped with outside air introduction devices 115 and 115 for taking the outside air into the air-conditioning unit 100, and outside air introduction ports 116 and 116 disposed on the outside air introduction devices 115 and 115 are formed so as to open toward the direction of travel of the railway car 1 (substantially parallel with the end structure 30). One of the outside air introduction ports 116 is opened toward one end in the longitudinal direction 520 of the railway car 1, and the other outside air introduction port 116 is opened toward the other end in the longitudinal direction 520 of the railway car 1. By disposing the outside air introduction ports 116 and 116 in the above-mentioned manner on the air-conditioning unit 100, the outside air can be taken in easily to the air-conditioning unit 100 regardless of which way the railway car 1 is driven.

[0026] An opening and closing apparatus 118 is disposed on the downstream side of the outside air introduction port 116.

[0027] Although not shown, multiple blades 122 capable of pivoting around shafts 123 are disposed within the opening and closing apparatus 118, as mentioned earlier, wherein by pivoting the blades around the shafts 123 in response to conditions mentioned later, the opening rate of the opening and closing apparatus 118 is adjusted to control the amount of outside air taken into the air-conditioning unit 100. A return opening 114 connected to an opening (not shown) disposed on the roof structure 40 of the railway car 1 is disposed on a bottom plate (not shown) of the air-conditioning unit 100.

[0028] The air from the inner side of the car being re-flown to the inner side of the air-conditioning unit 100 through the return opening 114 is mixed with the air from the outside introduced to the air-conditioning unit 100 through the outside air introduction port 116, passed through an indoor heat exchanger 112 and blown via an inside air fan 110 through the duct 48 disposed on the inner side of the car on the roof structure 40. The temperature of mixed air is measured via a temperature sensor 300 disposed on the upstream side of the indoor heat exchanger 112. Although not shown, a humidity sensor can be disposed together with the temperature sensor 300 to measure the humidity of mixed air.

[0029] Since the outside air introduction port 116 disposed on the side panel 105 of the air-conditioning unit 100 is arranged to open toward the direction of travel of the railway car 1, there is no need to provide an air fan for taking in outer air to the air-conditioning unit, and the relative flow of air generated when driving the railway car 1 can be utilized to take in outer air to the air-conditioning unit 100. Therefore, the manufacturing costs for an air fan for taking in outer air to the air-conditioning unit and

the consumption power regarding such air fan can be cut down.

[0030] The direction of travel of the railway car 1 is detected, based on which the opening and closing apparatuses 118 positioned on the opposite side from the direction of travel are completely closed, and the opening rate of the opening and closing apparatuses 118 positioned on the direction of travel is controlled based on the monitored result of the speed of the railway car 1, the temperature of the outer air and the temperature of the inside air. By operating only the evacuation air fan 200 when necessary to effectively introduce outer air into the railway car 1, the operation rate of the compressor, the outside air fan and the inside air fan of the air-conditioning unit 100 can be reduced, according to which the consumption power can be cut down.

[0031] FIG. 5 is a perspective view showing how air is introduced from the air intake port disposed on the upper portion of the end structure of the railway car into the duct disposed on the ceiling of the railway car. Air intake ports 32 and 32 (only one of which is shown) are formed at the upper portion of the end structures 30 and 30 disposed on both ends in the longitudinal direction 520 of the railway car 1 at the center of width 520 of the railway car 1, and an opening and closing apparatus 118 is disposed downstream from the air intake port 32.

[0032] Although not shown, as described earlier, the opening and closing apparatus 118 has a plurality of blades 122 capable of pivoting around shafts 123 built therein, and by pivoting the blades 122 around shafts 123 in response to conditions described later, the opening rate of the opening and closing apparatus 118 can be adjusted to control the quantity of outer air taken in through the air intake port 32 to the inner side of the railway car 1. A duct 48 arranged on an inner side of the car at the center in the width direction 510 of the roof structure 40 is disposed on the downstream side of the opening and closing apparatus 118, wherein the outside air 500 introduced through the air intake port 32 to the inner side of the railway car 1 is sent to various sections within the railway car 1.

[0033] Since the air intake port 32 disposed on the end structure 30 of the railway car 1 is opened toward the direction of travel of the railway car 1 (longitudinal direction 520 of the railway car 1), there is no need to dispose air fans or the like on the downstream side of the air intake port 32, and the outside air can be taken into the inner side of the railway car 1 utilizing the relative flow of air generated by driving the railway car 1. Therefore, the manufacturing costs of the air fan and the consumption power thereof can be cut down.

[0034] The direction of travel of the railway car 1 is detected, based on which the opening and closing apparatus 118 positioned on the opposite side from the direction of travel is completely closed (the opening rate is reduced), and the opening rate of the opening and closing apparatus 118 positioned on the direction of travel is controlled based on the monitored result of the speed of the

railway car 1, the temperature of the outer air and the temperature of the inside air. By operating the evacuation air fan 200 only when necessary to effectively introduce outer air into the railway car 1, the operation rate of the compressor, the outside air fan and the indoor air fan of the air-conditioning unit 100 can be reduced, according to which the consumption power can be cut down.

[0035] Fig. 6 is a perspective view of an air intake device disposed on the rooftop of the railway car. Air intake systems 42 and 42 (only one of which is shown) are disposed on the upper side on both ends in the longitudinal direction 520 of the roof structure 40 constituting the railway car 1. An opening 44 for taking in outer air is disposed on the end structure 30-side of the air intake device 42, and on the downstream side of the opening 44 is disposed an opening and closing apparatus 118.

[0036] An opening (not shown) communicated with a duct 48 (refer to Fig. 5) disposed along the longitudinal direction of the railway car 1 is disposed on the roof structure 40 directly below the opening and closing apparatus 118, and the outer air introduced to the railway car 1 via the air intake device 42 is supplied to various sections within the railway car 1.

[0037] Although not shown, the opening and closing apparatus 118 has a plurality of blades 122 capable of pivoting around shafts 123 built therein as mentioned earlier, and by pivoting the blades 122 around the shafts 123 based on conditions described later, the opening rate of the opening and closing apparatus 118 is controlled to adjust the quantity of outer air taken into the railway car 1 via the air intake device 42. According to Fig. 6, an example is shown in which two air intake devices 42 are disposed on one end of the roof structure 40, but the number and position of the air intake device 42 is not restricted thereto, and an arbitrary number of air intake devices can be disposed on the side structure or the underframe.

[0038] Since the air intake port 44 of the air intake device 42 is opened toward the direction of travel of the railway car 1 (longitudinal direction 520 of the railway car 1), outside air can be taken into the inner side of the railway car 1 using the relative flow of air generated by driving the railway car 1 without having to dispose air fans within the air intake device 42. Thus, the manufacturing costs of air fans and consumption power related to operating the same can be cut down.

[0039] The direction of travel of the railway car 1 is detected, based on which the opening and closing apparatus 118 positioned on the opposite side from the direction of travel is reduced (completely closed), and the opening rate of the opening and closing apparatus 118 positioned on the direction of travel is controlled based on the monitored result of the speed of the railway car 1, the temperature of the outside air and the temperature of the inside air. By operating the evacuation air fan 200 only when necessary to effectively introduce outer air into the railway car 1, the operation rate of the compressor, the outside air fan and the indoor air fan of the air-

conditioning unit 100 can be reduced, according to which the consumption power can be cut down.

[0040] Fig. 7 is a vertical longitudinal cross-sectional view of the air-conditioning unit disposed on the rooftop of the railway car and the railway car. An air-conditioning unit 100 is disposed on the upper side of the roof structure 40 constituting the railway car 1. Since the air-conditioning unit 100 is symmetric in the width direction 510 with respect to the center line 450, only one side in the width direction 510 of the air-conditioning unit 100 is illustrated in Fig. 7. A return opening 114 for taking in the air inside the car into the air-conditioning unit 100 is disposed on the lower side at the end in the width direction 510 of a bottom panel 106 of the air-conditioning unit 100. A side panel 105 erected at the width-direction end of the air-conditioning unit 100 has an opening 107 for taking in outside air to the air-conditioning unit. Further, the air-conditioning unit 100 shown in Fig. 7 does not have any opening and closing apparatus 118 disposed on the side panel 105 of the air-conditioning unit 100 shown in Fig. 4.

[0041] A distributor 120 is disposed within the air-conditioning unit where the width direction end of the bottom panel 106 of the air-conditioning unit 100 and the lower end of the side panel 105 cross. The distributor 120 is composed of a panel section 121 and a shaft 123 supporting one end of the panel section 121 in a pivotable manner. By pivoting the panel section 121 of the distributor 120 around the shaft 123 and maintaining the same at a substantially perpendicular position, the amount of air 500 from the outer side of the car introduced to the inner side of the air-conditioning unit 100 can be reduced and the amount of air 505 from the inner side of the car returned to the inner side of the air-conditioning unit 100 can be increased. Furthermore, by pivoting the panel section 121 of the distributor 120 around the shaft 123 and maintaining the same at a substantially horizontal position, the amount of air 500 from the outer side of the car introduced to the inner side of the air-conditioning unit 100 can be increased and the amount of air 505 from the inner side of the car returned to the inner side of the air-conditioning unit 100 can be reduced. If it is difficult to arbitrarily control the flow ratio of the amount of air 500 from the outer side of the car and the amount of air 505 from the inner side of the car introduced to the air-conditioning unit 100 just by controlling the inclination of the distributor 120, the indoor air fan 110 disposed on the inner side of the air-conditioning unit 1 (refer to Fig. 4) can be operated. Further, if it is difficult to take in outer air into the air-conditioning unit 100 only by controlling the position of the distributor 120, it is possible to dispose the outside air introduction device 115 as described in Fig. 4 so as to cover the opening 107 disposed on the side panel 105 erected at the width direction end of the air-conditioning unit 100. The present arrangement can exert effects similar to the embodiment of Fig. 4, that is, effects including easily taking in outer air to the air-conditioning unit 100.

[0042] Further, by disposing a distributor 120 in the

inner side of the air-conditioning unit 100 and controlling only the position of the distributor 120 based on the outside temperature and the inside temperature, the flow ratio of the amount of air 500 taken in from the outer side of the car into the air-conditioning unit 100 and the amount of air 505 from the inner side of the car can be controlled. If the speed of the railway car 1 is small and it is difficult to introduce outside air into the air-conditioning unit 100, the evacuation air fan 200 disposed on the railway car 1 is operated to discharge the inside air of the railway car 1 to the exterior to reduce the pressure within the car to be smaller than the pressure outside the car, according to which the outside air of the car can be introduced to the inner side of the air-conditioning unit 100 (inner side of the railway car 1). As a result, the inner temperature of the railway car 1 can be controlled without operating the air-conditioning unit 1, so that the consumption power can be cut down.

[0043] Fig. 8 is a cross-sectional view of a side sliding door disposed on one side structure of the railway car and a door case for storing the side sliding door taken along the height (vertical) direction of the railway car. Doors 24 allowing passengers to board and alight the car are disposed on the side structure 20 constituting the side wall of the railway car 1, and side sliding doors 26 are disposed in the doors 24 capable of opening and closing along the longitudinal direction 520 of the railway car 1. Door cases 27 are disposed on the inner side of the side structure 20 at both width-direction (longitudinal direction 520 of the railway car 1) ends of the door 24 for storing the side sliding doors when they are opened. Seats 29 are arranged on the upper side of the floor 12 on the inner side the car of the door cases 27.

[0044] Fig. 9 is a C-C cross-section of Fig. 8, showing a positional relationship in the height direction of an opening disposed on the door case and an opening and closing apparatus for evacuation disposed on the side structure. The opening disposed on the side structure 20 is equipped with an opening and closing apparatus 118. As mentioned earlier, the opening and closing apparatus 118 has built therein shafts 123 and multiple blades 122 capable of pivoting around shafts 123, wherein by pivoting the blades 122 around the shafts 123 in response to conditions mentioned later, the opening rate of the opening and closing apparatus 118 is adjusted to control the amount of air discharged to the exterior from the inner side of the railway car 1.

[0045] Openings 28 are formed on the door case 27 in which the side sliding doors 26 are stored. The height from the upper surface of the floor 12 to the opening and closing apparatus 118 disposed on the side structure 20 and the height from the upper surface of the floor 12 to the opening 28 formed on the door case 27 are separated by distance H3 in the height direction. Therefore, even if the rolling noise or the like caused by the wheels rotating on the rails enters the railway car 1 through the opening and closing apparatus 118, the noise is attenuated in the process being diffracted along the height direction within

the door case 27, so the noise is not easily released to the inner side of the railway car 1 through the opening 28 disposed on the door case 27. Although not shown, by separating the opening 28 disposed on the door case 27 and the opening and closing apparatus 118 disposed on the side structure 20 by a predetermined distance along the longitudinal direction of the railway car 1 and diffracting the flow of air 500 from the inner side of the railway car 1 to the outer side, the same effect can be achieved. Further, a sound absorbing material or the like can be attached to the side facing the side structure 20 of the door case 27.

[0046] Fig. 10 is a block diagram showing the data entered to the control unit and the object of control of the control unit. The data entered to the control unit 16 include speed data and position data of the railway car, inside pressure and the outside pressure (atmospheric pressure) of the railway car, inside temperature and outside temperature of the railway car, inside humidity and outside humidity of the railway car, boarding rate, carbon dioxide concentration within the railway car, fire detection data from a fire detector disposed on the respective railway cars, and side sliding door (door) open/close data when the train is stopped at a station. Based on these input data, the control unit 16 outputs commands such as a cooling operation command or a heating operation command to the air-conditioning unit 100, an opening rate control of the opening and closing apparatus 118 for intake or outlet, a position control of the distributor 120 disposed on the inner side of the air-conditioning unit 100, and an operation command for the evacuation air fan 200.

[0047] Not all these input data are necessary, and based on the input data selected as needed from the above-listed input data, the air-conditioning unit 100, the opening and closing apparatus 118 and the evacuation air fan 200 are controlled.

[0048] Fig. 11 is a view showing one preferred embodiment of a control law of the control unit shown in Fig. 10. Fig. 11 assumes that a set target temperature of the inside of the car is 22 °C when the railway car 1 is driven at high speed.

[0049] When the inside temperature and the outside temperature fall within the state of A in the drawing (for example, point a: inside temperature 25 °C, outside temperature 19 °C) the air-conditioning unit 100 performs cooling operation since the inside temperature is higher than outside temperature. At this time, in order to reduce the operation rate of the air-conditioning unit 100 and cut down the consumption power thereof by approximating the inside temperature of the railway car 1 to the set target temperature in a shorter time, the outside temperature cooler than the inside temperature is introduced to the railway car. Actually, the opening rates of the opening and closing apparatus 118 disposed on the downstream side of the air intake port 32 disposed on the end structure 30, the opening and closing apparatus 118 disposed on the air intake device 42 arranged on the roof structure 1

and the opening and closing apparatus 118 disposed on the outside air introduction device 115 arranged on the side panel 105 of the air-conditioning unit 100 are set high, and the opening rates of the opening and closing apparatus 118 disposed on the end structure 30 and the opening and closing apparatus 118 disposed on the side structure 20 are set high. At this time, the railway car 1 is driven at high speed, but in order to take in a large amount of outside air into the railway car 1, the evacuation air fan 200 is operated.

[0050] When the inside temperature and the outside temperature fall within the state of B (for example, point b: inside temperature 23 °C, outside temperature 18 °C), the difference between the outside temperature and the inside temperature is small, so outside air is taken into the railway car 1 instead of performing cooling operation of the air-conditioning unit 100. The opening rates of the opening and closing apparatuses 118 disposed on the air intake port 32, the air intake device 42 and the outside air introduction device 115 are set high, and the opening rates of the opening and closing apparatuses 118 of the outlet 34 and the end structure 20 are set high. Since the railway car 1 is driven at high speed, outside air is introduced to the inner side of the railway car 1 through any of the outside air introduction port 116 of the outside air introduction device 115, the air intake port 32 or the air intake port 44 of the air intake device 42 disposed to open toward the direction of travel of the railway car 1, and the inside air containing heat within the railway car 1 is discharged to the outside through the opening and closing apparatuses 118 on the outlet 34 and the end structure 20, so that the inside temperature of the railway car 1 is approximated to the set target temperature without operating the air-conditioning unit 100, according to which the consumption power can be reduced.

[0051] When the inside temperature and the outside temperature is in the state of C in the drawing (for example, point c: inside temperature 20 °C, outside temperature 16 °C), the air-conditioning unit 100 performs heating operation since the inside temperature is lower than outside temperature and also lower than the set target temperature. Therefore, the opening rates of the opening and closing apparatuses 118 disposed on the air intake port 32, the air intake device 42 and the outside air introduction device 115 are set low and the opening rates of the opening and closing apparatuses 118 of the outlet 34 and the end structure 20 are also set low. At this time, the opening rates of the opening and closing apparatuses 118 are controlled to ensure the minimum necessary ventilation quantity by referring to the boarding rate or the detection result of the carbon dioxide gas concentration (refer to Fig. 10). Since this control enables to minimize the amount of air taken in from the outside having a temperature lower than the inside air of the railway car 1, the frequency of heating operation can be reduced and the consumption power can be cut down. Further, the heating operation can be performed via a heat pump operation using a cooling cycle disposed on the air-conditioning

unit 100, a heater disposed on the inner side of the air-conditioning unit 100 or a heater disposed under the seats 29 (refer to Fig. 9) of the railway car 1.

[0052] When the inside temperature and the outside temperature are in the state of D in the drawing (for example, point d1: inside temperature 24 °C, outside temperature 22 °C), the air-conditioning unit 100 performs cooling operation since the inside temperature is higher than outside temperature and also higher than the set target temperature. Moreover, according to another condition in state D of the drawing (for example, point d2: inside temperature 20 °C, outside temperature 19 °C), the air-conditioning unit 100 or the heater performs heating operation since the inside temperature is higher than outside temperature and lower than the set target temperature.

[0053] According to these conditions, the opening rates of the opening and closing apparatuses 118 disposed on the air intake port 32, the air intake device 42 and the outside air introduction device 115 are set low, and the opening rates of the opening and closing apparatuses 118 of the outlet 34 and the end structure 20 are also set low. At this time, the opening rates of the opening and closing apparatuses 118 are controlled to ensure the minimum necessary ventilation quantity by referring to the detection result of the carbon dioxide gas concentration (refer to Fig. 10) or the boarding rate.

[0054] In this state, cooling operation or heating operation of the air-conditioning unit 100 is selected to approximate the inside temperature to the set target temperature, but in any case, the amount of air taken in from the outside to the inside is minimized, so that the frequency of cooling operation or heating operation can be reduced and the consumption power can be cut down.

[0055] A fire detector is respectively disposed on the railway cars constituting a trainset in which multiple cars are connected, to comprehend the car in which fire occurred. When fire occurs, fire detection data (refer to Fig. 10) is transmitted from the fire detector disposed on that car to the control unit 16, and the car in which fire occurred is displayed on a monitor disposed on the driver's seat and the crew's cabin. It is important to prevent smoke from flowing from the car in which fire occurred to adjacent cars and to prevent fire from spreading within the trainset, since evacuation of passengers will become difficult. Therefore, when fire detection data from a car is transmitted to the control unit 16, the cooling operation and heating operation via the air-conditioning unit 100 and the heater disposed under the seats 29 of that car are stopped regardless of the inside temperature and the outside temperature, and the opening rates of the opening and closing apparatuses 118 disposed on the air intake port 32, the air intake device 42 and the outside air introduction device 115 and the opening rates of the opening and closing apparatuses 118 of the outlet 34 and the end structure 20 of this car are set to a minimum. The evacuation air fan 200 of this car is operated to maintain the inside pressure of this car to be lower than the

inside pressure of the other railway cars adjacent thereto, so as to prevent the intrusion of smoke or fire or spreading of fire from this car to adjacent cars.

[0056] According to the embodiment shown in Fig. 11, the control unit 16 controls the air-conditioning unit 100, the opening rates of the various opening and closing apparatuses 118 and the evacuation air fan 200 based on the inside temperature and the outside temperature, but in addition to inside and outside temperatures, the control can be performed based on the enthalpy of inside air and enthalpy of outer air computed based on the inside humidity and outside humidity, or based on the passenger load with respect to the air-conditioning unit 100 computed based on the number of passengers.

[0057] Fig. 12 is a timing chart of the operation of the railway car speed, the evacuation air fan, the opening and closing apparatus for air intake and the opening and closing apparatus for air outlet according to a preferred embodiment of the present invention. The timing chart shown in Fig. 12 illustrates an example in which the railway car in the state shown in area B of Fig. 11 starts to travel toward the next station after confirming that the doors have been closed while the train is stopped at a station, wherein the speed (km/h) of the railway car 1, the operation status of the evacuation air fan 200, and the states of operation of the air intake-side opening and closing apparatuses 118 (disposed in the air intake port 32, the air intake device 42 and the outside air introduction device 115) and the air outlet-side opening and closing apparatuses 118 (opening and closing apparatuses disposed on the outlet 34 and the end structure 20) are shown in time series.

[0058] When the side sliding doors 26 disposed on the side structure 20 of the railway car 1 are closed, the door (open) close data (refer to Fig. 10) is entered to the control unit 16. The control unit 16 having received input of the door close signal outputs a command to operate the evacuation air fan 200 and to set the opening rates of the intake-side opening and closing apparatuses 118 to be high. Since the evacuation air fan 200 is operated, the opening rates of the opening and closing apparatuses 118 are controlled to be small. In this state, when the railway car 1 continues acceleration and reaches time A, in order to prevent outer air from being taken excessively into the railway car 1 and to maintain a most suitable inside temperature of the railway car 1, the opening rates of the intake-side opening and closing apparatuses 118 are controlled low and the opening rates of the outlet-side opening and closing apparatuses 118 are controlled high.

[0059] At time B, since the speed of the railway car 1 is high and sufficient amount of outside air can be taken into the railway car 1 through the intake-side openings opened toward the direction of travel of the railway car 1 such as the air intake port 32, the air intake device 42 and the outside air introduction device 115 without having to operate the evacuation air fan 200, the operation of the evacuation air fan 200 is stopped.

[0060] From time C to time D, the railway car 1 is driven at high speed, so in order to taken in a predetermined amount of outside air into the railway car 1 while the operation of the evacuation air fan 200 is stopped, the opening rates of the intake-side opening and closing apparatuses 118 and the outlet-side opening and closing apparatuses 118 are respectively controlled.

[0061] At time E, the railway car 1 starts deceleration for preparation to stop at a station, so in order to introduce the predetermined amount of outside air into the railway car 1 regardless of the deceleration of the railway car 1, the opening rates of the intake-side opening and closing apparatuses 118 are set high and the opening rates of the outlet-side opening and closing apparatuses 118 are set low since the evacuation air fan 200 is restarted.

[0062] At time F, the railway car 1 stops at a station and the speed thereof becomes 0 km/h, and the side sliding doors 26 are opened. The control unit 16 having received the door open (close) data of the side sliding doors 26 stops the operation of the evacuation air fan 200, sets the opening rates of the intake-side opening and closing apparatuses to a high value and the opening rates of the outlet-side opening and closing apparatuses to a low value.

[0063] Instead of operating the air-conditioning unit 100, by utilizing the relative flow of air generated between the railway car 1 and the outside air when the railway car 1 is driven, the outside air can be taken into the railway car 1 without operating the evacuation air fan 200 when the railway car 1 is driven at a predetermined speed or higher. Therefore, the temperature inside the railway car 1 can be approximated to the set target temperature without operating the air-conditioning unit 100 and the evacuation air fan 200, so that the consumption power can be cut down.

Claims

1. A railway car (1) comprising an air intake device (32, 42, 115) for introducing outside air into the car and having an opening and closing apparatus (118), an evacuation device having an opening and closing apparatus (118), an evacuation air fan (200) for evacuating the inside air to the exterior of the car, an air-conditioning unit (100) for controlling a temperature and a humidity inside the car, and a control unit (16) for controlling the air intake device, the evacuation device, and the evacuation air fan, wherein the railway car further comprises a first evacuation flow path equipped with the evacuation device, and a second evacuation flow path arranged in parallel with the first evacuation flow path and equipped with the evacuation air fan (200), **characterised in that** the control unit (16) is arranged to detect outside temperature and inside temperature of the railway car and speed data of the railway car, and is arranged to control (a) the opening rate of the opening and

closing apparatus (118) of the air intake device, (b) the opening rate of the opening and closing apparatus (118) of the evacuation device, and (c) the evacuation air fan (200) on the basis of the inside temperature, the outside temperature and the speed data of the railway car.

2. The railway car according to claim 1, wherein the air intake device (32, 42, 115) comprises an opening (44, 116) opened toward a direction of travel of the railway car, and the opening and closing apparatus of the air intake device is disposed downstream from the opening and controlled via the control unit for adjusting an opening rate of an air intake flow path through which outside air is taken into the car.
3. The railway car according to claim 2, wherein the opening of the air intake device (32) is disposed on an upper portion of an end structure (30) of the railway car at a center in a width direction (510) of the end structure, the opening being connected to a duct (48) disposed on a ceiling portion (40) of the railway car and arranged along a longitudinal direction (520) of the railway car, and wherein the opening and closing apparatus of the air intake device is disposed on the duct downstream from the opening.
4. The railway car according to claim 2, **characterized in that** the air-conditioning unit has a side panel (105) erected at a width-direction end of the air-conditioning unit and an opening formed on the side panel, wherein the air intake device (115) is disposed on the side panel so as to cover the opening, and the opening and closing apparatus constituting the air intake device is disposed on the opening of the side panel.

Patentansprüche

1. Eisenbahnwaggon (1), umfassend: eine Lufteinlassvorrichtung (32, 42, 115) zum Einführen von Außenluft in den Waggon, die eine Öffnungs- und eine Schließeinrichtung (118) aufweist, eine Evakuierungsvorrichtung, die eine Öffnungs- und eine Schließeinrichtung (118) aufweist, einen Luft-Evakuierungsventilator (200) zum Evakuieren der Innenluft an die Außenseite des Waggons, eine Klimaanlageeinheit (100) zum Steuern der Temperatur und einer Luftfeuchtigkeit innerhalb des Waggons, und eine Steuereinheit (16) zum Steuern der Lufteinlassvorrichtung, der Evakuierungsvorrichtung und des Luft-Evakuierungsventilators, wobei der Eisenbahnwaggon ferner einen mit der Evakuierungsvorrichtung ausgestatteten ersten Evakuierungsströmungspfad und einen parallel zu dem ersten Evakuierungsströmungspfad angeordneten

und mit dem Luft-Evakuierungsventilator (200) ausgestatteten zweiten Evakuierungsströmungspfad umfasst, **dadurch gekennzeichnet, dass** die Steuereinheit (16) dazu ausgelegt ist, die Außen- und die Innentemperatur des Eisenbahnwaggons und Geschwindigkeitsdaten des Eisenbahnwaggons zu erfassen, und (a) das Öffnungsmaß der Öffnungs- und Schließeinrichtung (118) der Lufteinlassvorrichtung, (b) das Öffnungsmaß der Öffnungs- und Schließeinrichtung (118) der Evakuierungsvorrichtung, und (c) den Luft-Evakuierungsventilator (200) auf Grundlage der Innentemperatur, der Außentemperatur und der Geschwindigkeitsdaten des Eisenbahnwaggons zu steuern.

2. Eisenbahnwaggon nach Anspruch 1, wobei die Lufteinlassvorrichtung (32, 42, 115) eine Öffnung (44, 116) umfasst, die zur Fahrtrichtung des Eisenbahnwaggons hin geöffnet ist, und die Öffnungs- und Schließeinrichtung der Lufteinlassvorrichtung zu der Öffnung nachgelagert angeordnet ist und über die Steuereinheit zum Anpassen eines Öffnungsmaßes eines Lufteinlassströmungspfades, durch den Außenluft in den Waggon aufgenommen wird, gesteuert wird.
3. Eisenbahnwaggon nach Anspruch 2, wobei die Öffnung der Lufteinlassvorrichtung (32) an einem oberen Abschnitt einer Endstruktur (30) des Eisenbahnwaggons mittig in Breitenrichtung (510) der Endstruktur angeordnet ist, wobei die Öffnung mit einem Schacht (48) verbunden ist, der an einem Dachabschnitt (40) des Eisenbahnwaggons angeordnet ist und entlang einer Längsrichtung (520) des Eisenbahnwaggons angeordnet ist, und wobei die Öffnungs- und Schließeinrichtung der Lufteinlassvorrichtung in dem Schacht zu der Öffnung nachgelagert angeordnet ist.

4. Eisenbahnwaggon nach Anspruch 2, **dadurch gekennzeichnet, dass** die Klimaanlageeinheit ein Seitenpaneel (105), das an einem Breitenrichtungs-ende der Klimaanlageeinheit aufgerichtet ist, und eine an dem Seitenpaneel gebildete Öffnung umfasst, wobei die Lufteinlassvorrichtung (115) an dem Seitenpaneel so angeordnet ist, dass sie die Öffnung abdeckt, und wobei die Öffnungs- und Schließeinrichtung, die die Lufteinlassvorrichtung erzeugt, an der Öffnung des Seitenpaneels angeordnet ist.

Revendications

1. Voiture de chemin de fer (1) comportant un dispositif d'admission d'air (32, 42, 115) pour introduire de l'air extérieur dans la voiture et ayant un appareil d'ouverture et de fermeture (118), un dispositif d'évacuation ayant un appareil d'ouverture et de fermeture (118),

un ventilateur d'air d'évacuation (200) pour évacuer l'air intérieur à l'extérieur de la voiture, une unité de climatisation (100) pour commander une température et une humidité à l'intérieur de la voiture, et une unité de commande (16) pour commander le dispositif d'admission d'air, le dispositif d'évacuation, et le ventilateur d'air d'évacuation, dans lequel la voiture de chemin de fer comporte en outre un premier trajet d'écoulement d'évacuation équipé du dispositif d'évacuation, et un second trajet d'écoulement d'évacuation disposé parallèlement au premier trajet d'écoulement d'évacuation et équipé du ventilateur d'air d'évacuation (200), **caractérisée en ce que** l'unité de commande (16) est conçue pour détecter la température extérieure et la température intérieure de la voiture de chemin de fer et des données de vitesse de la voiture de chemin de fer, et est conçue pour commander (a) la vitesse d'ouverture de l'appareil d'ouverture et de fermeture (118) du dispositif d'admission d'air, (b) la vitesse d'ouverture de l'appareil d'ouverture et de fermeture (118) du dispositif d'évacuation, et (c) le ventilateur d'air d'évacuation (200) sur la base de la température intérieure, de la température extérieure et des données de vitesse de la voiture de chemin de fer.

2. Voiture de chemin de fer selon la revendication 1, dans laquelle :

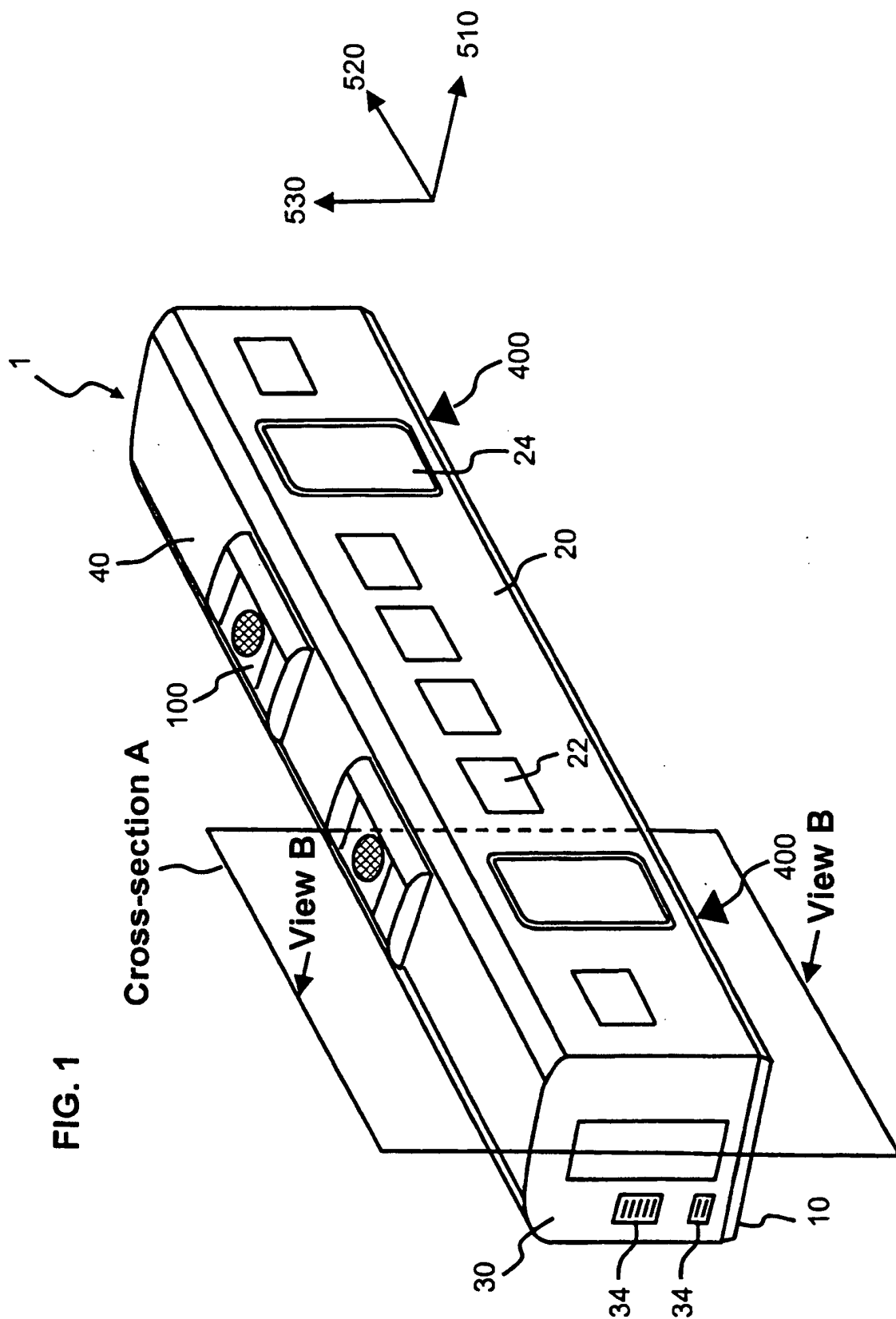
le dispositif d'admission d'air (32, 42, 115) comporte une ouverture (44, 116) ouverte dans une direction de déplacement de la voiture de chemin de fer, et l'appareil d'ouverture et de fermeture du dispositif d'admission d'air est disposé en aval de l'ouverture et commandé par l'unité de commande pour régler la vitesse d'ouverture d'un trajet d'écoulement d'admission d'air à travers lequel l'air extérieur est prise dans la voiture.

3. Voiture de chemin de fer selon la revendication 2, dans laquelle :

l'ouverture du dispositif d'admission d'air (32) est disposée sur une partie supérieure d'une structure d'extrémité (30) de la voiture de chemin de fer au centre dans une direction de largeur (510) de la structure d'extrémité, l'ouverture étant reliée à une conduite (48) disposée sur une partie de plafond (40) de la voiture de chemin de fer et disposée le long d'une direction longitudinale (520) de la voiture de chemin de fer, et dans laquelle l'appareil d'ouverture et de fermeture du dispositif d'admission d'air est disposé sur la conduite en aval de l'ouverture.

4. Voiture de chemin de fer selon la revendication 2, **caractérisée en ce que**

l'unité de climatisation a un panneau latéral (105) installé à une extrémité dans le sens de la largeur de l'unité de climatisation et une ouverture formée sur le panneau latéral, le dispositif d'admission d'air (115) étant disposé sur le panneau latéral de façon à recouvrir l'ouverture, et l'appareil d'ouverture et de fermeture constituant le dispositif d'admission d'air étant disposé sur l'ouverture du panneau latéral.



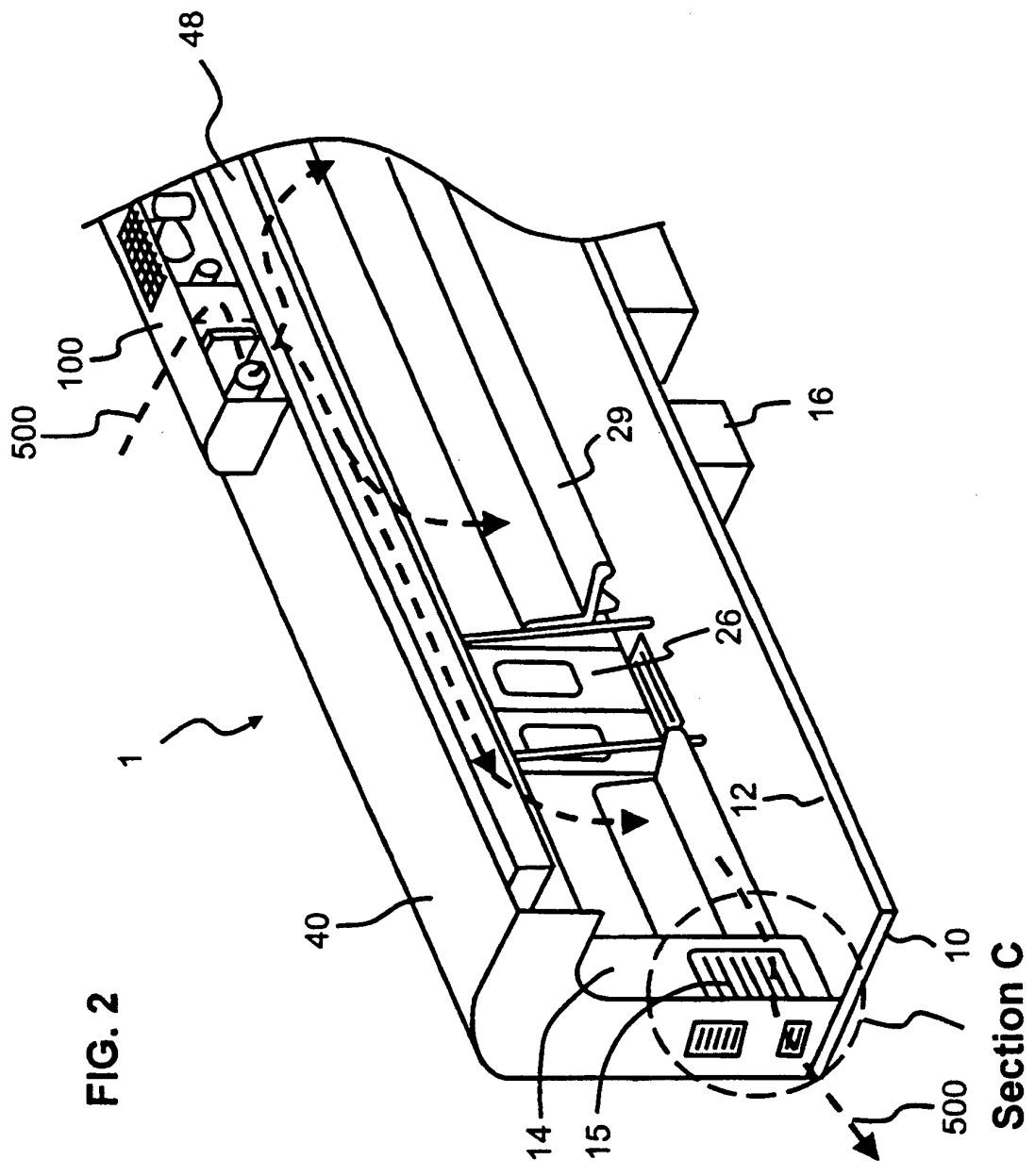
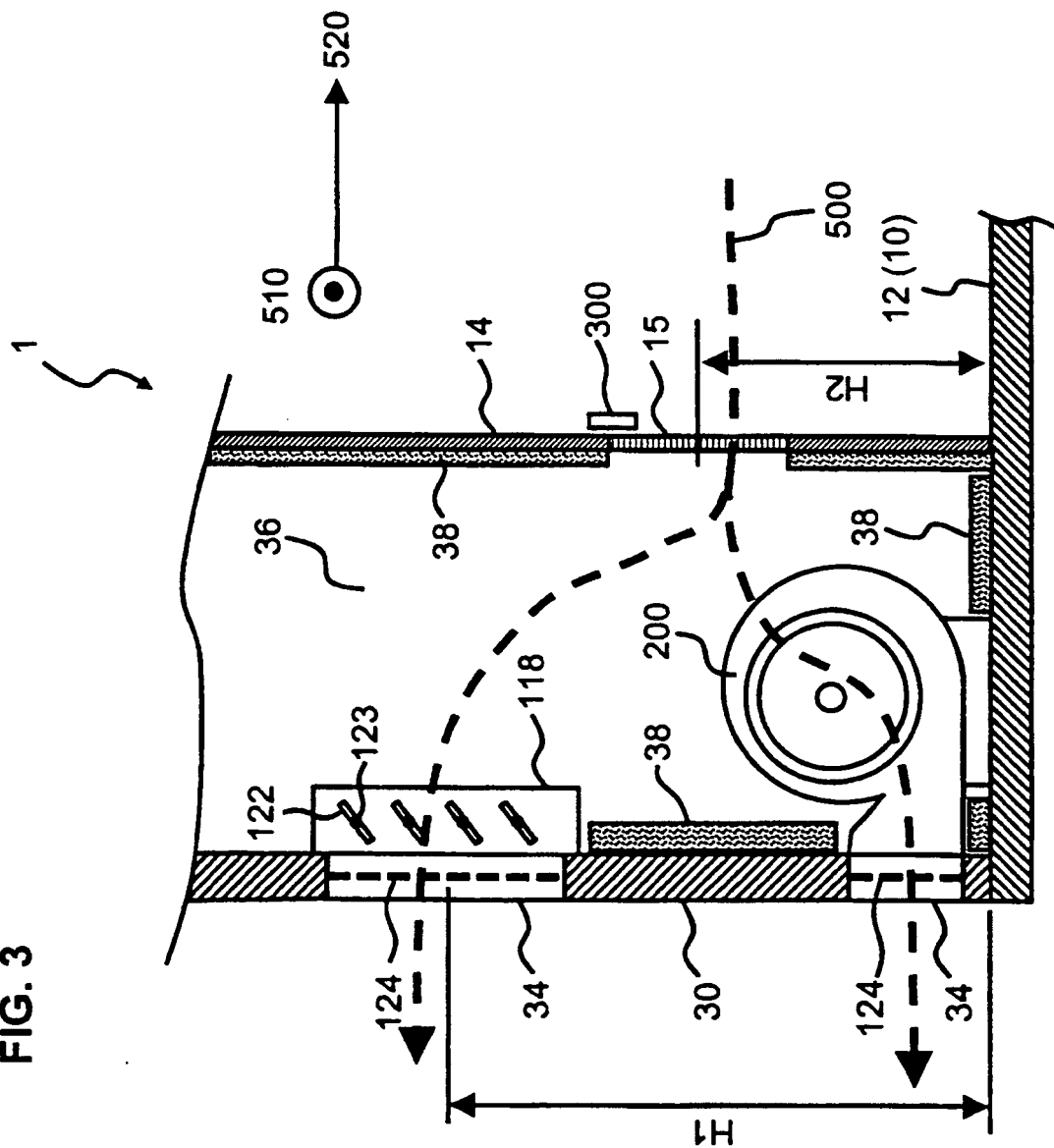


FIG. 3



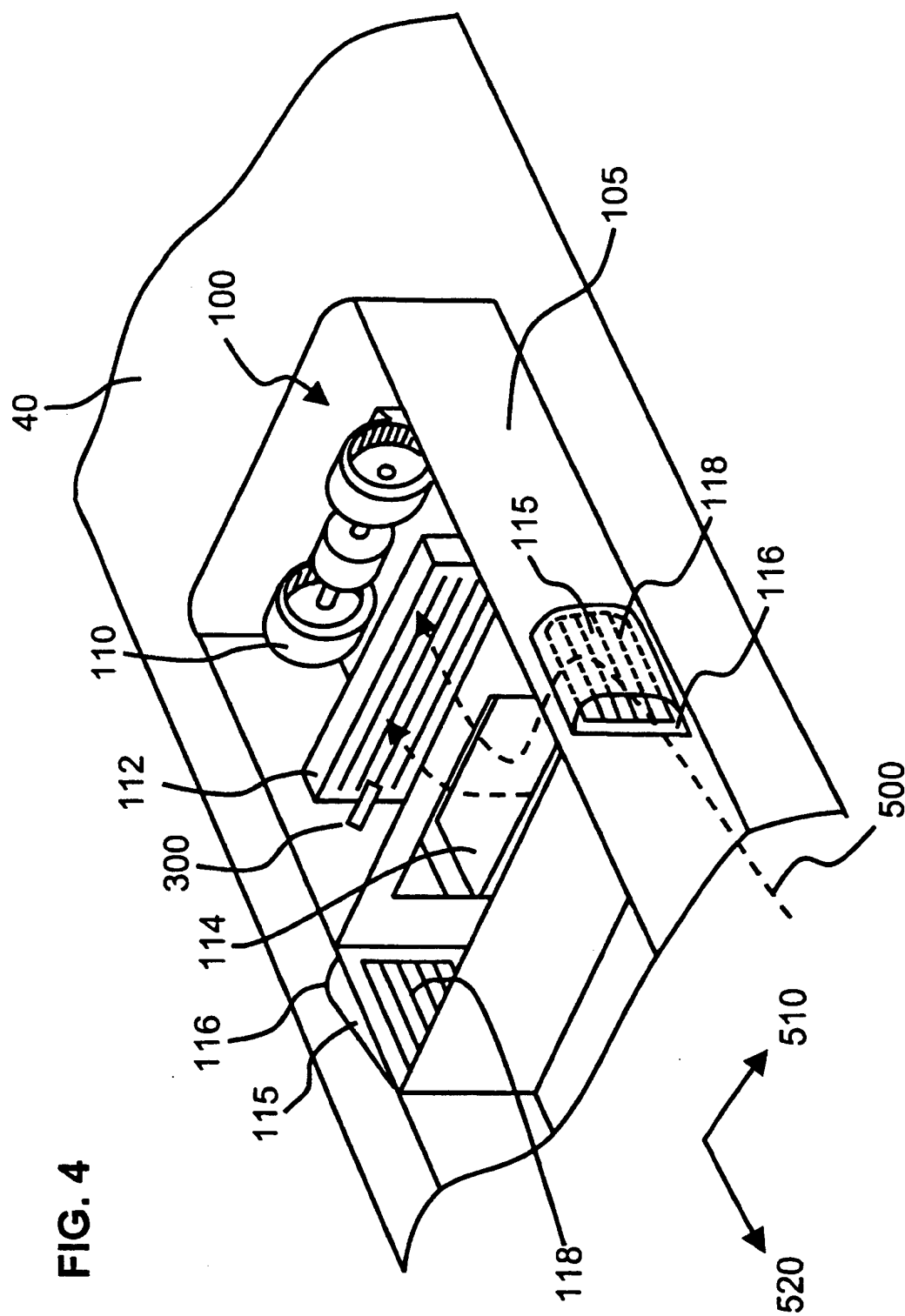
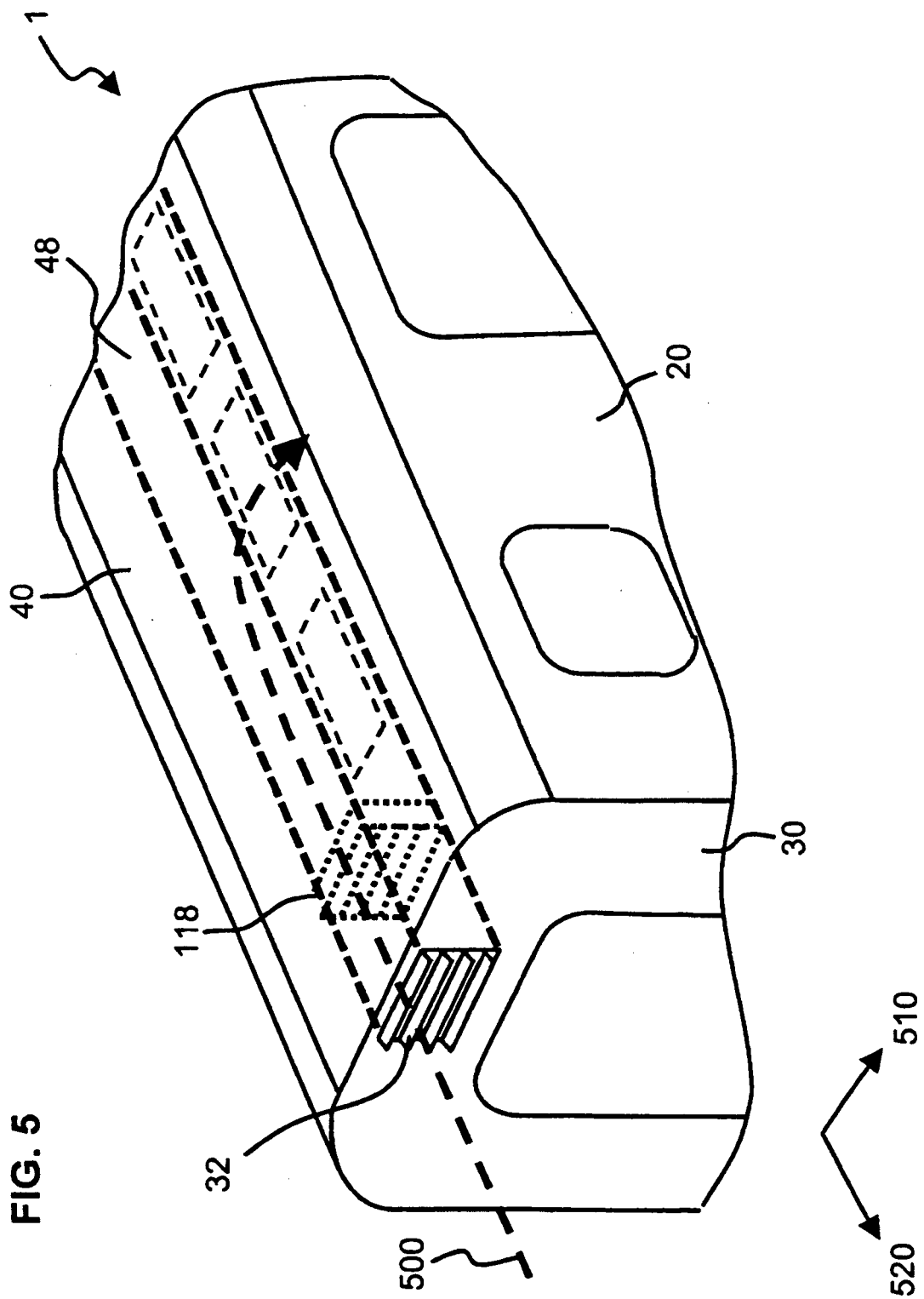
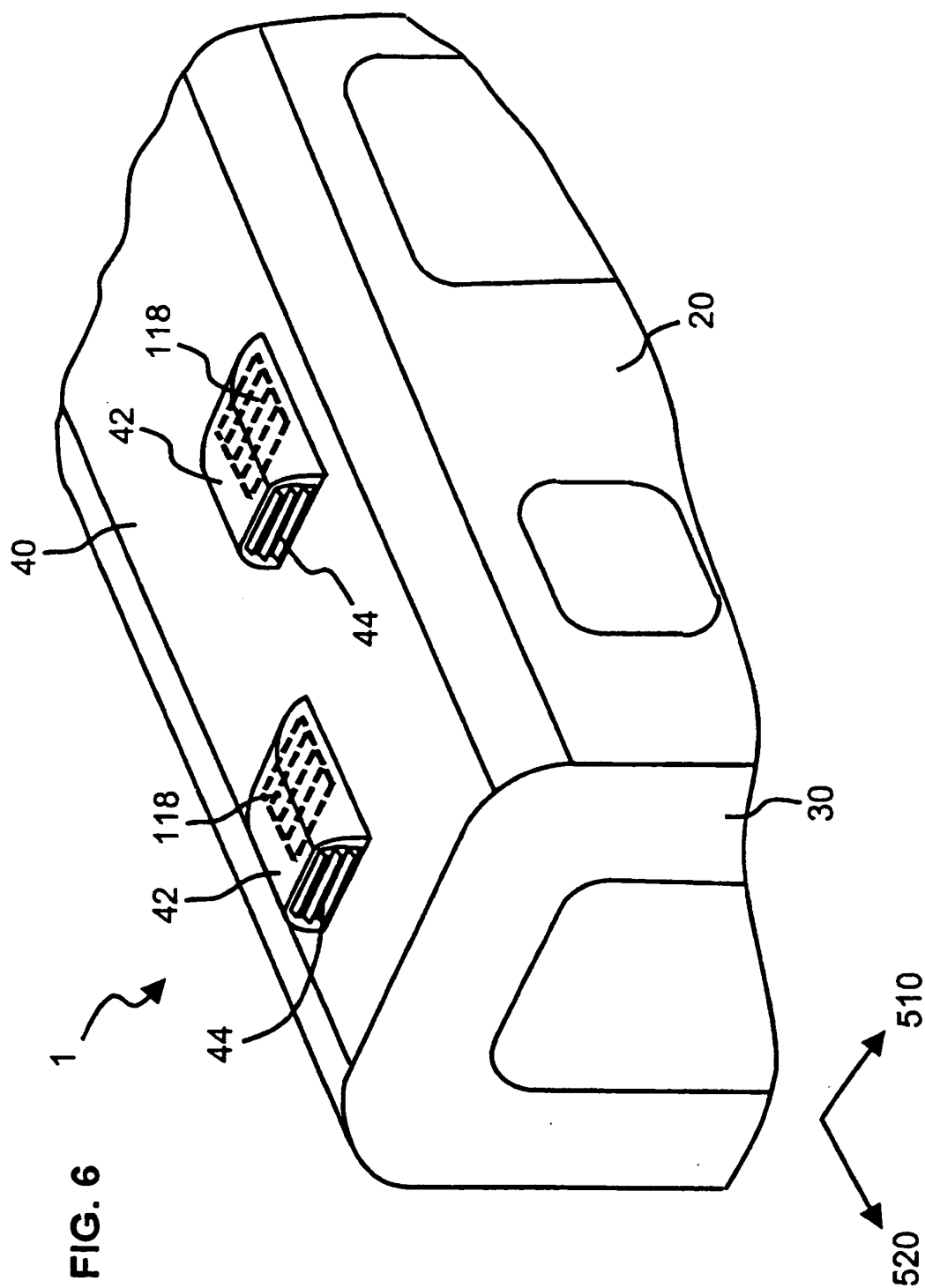


FIG. 4





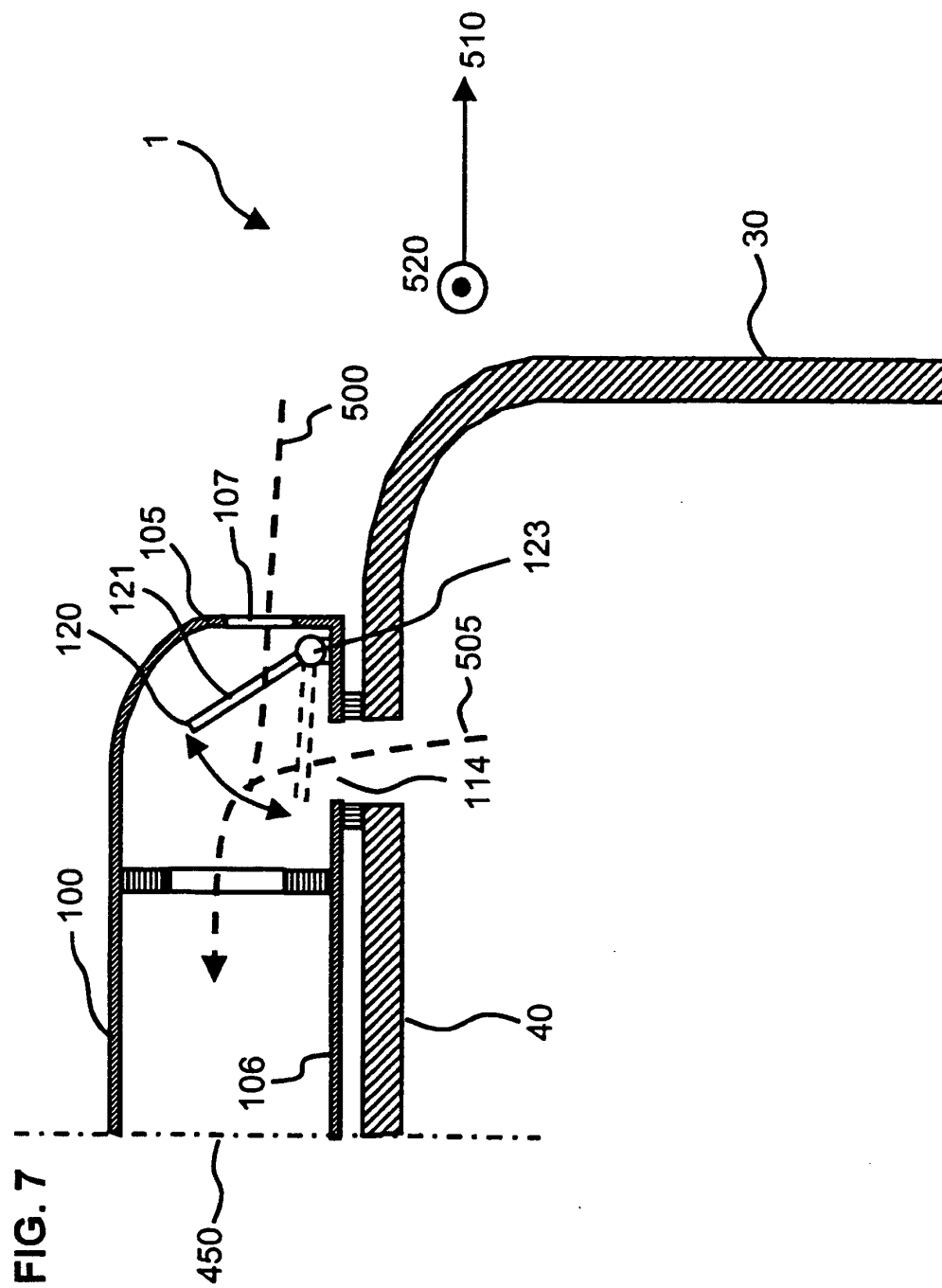
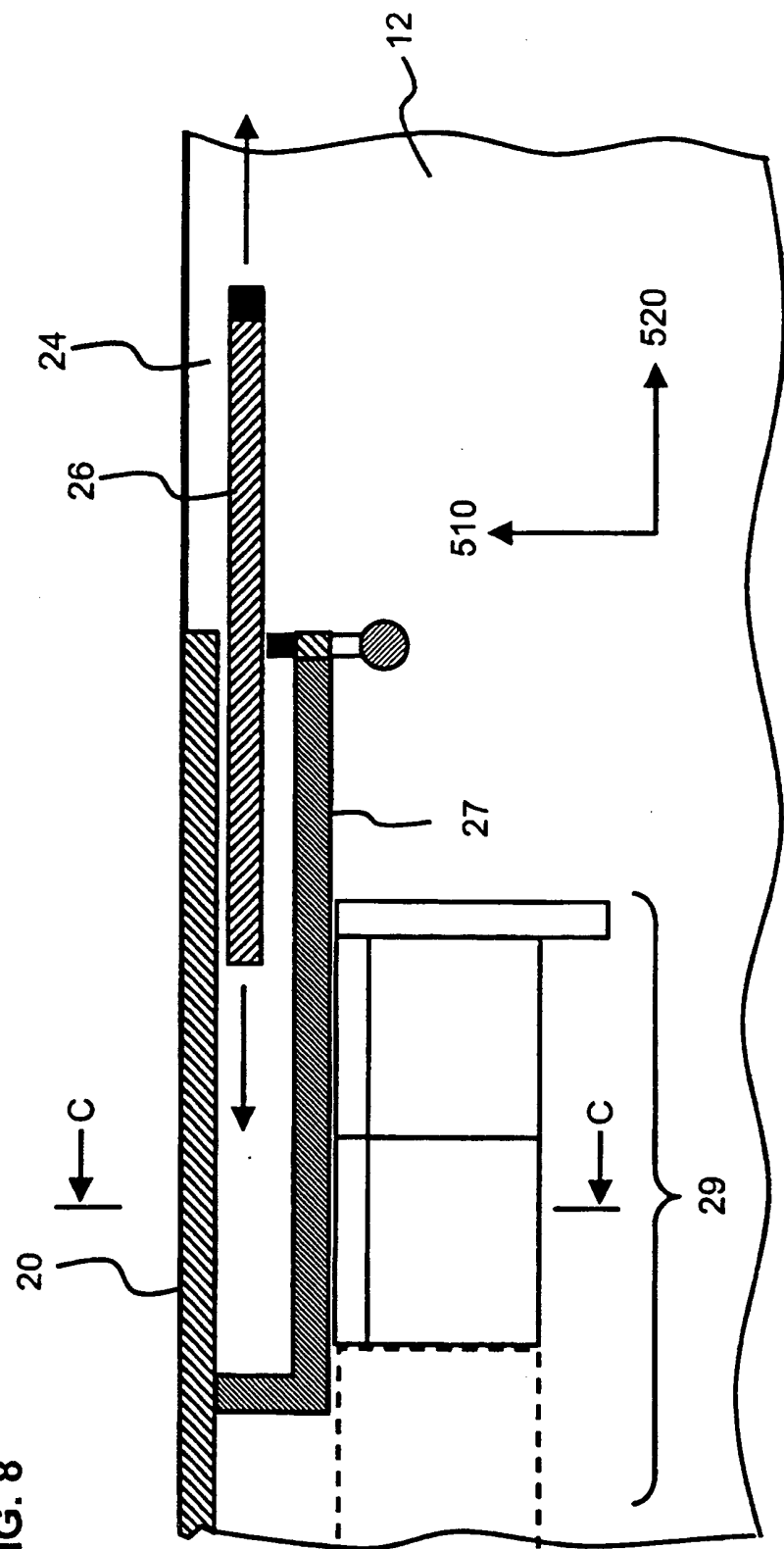


FIG. 8



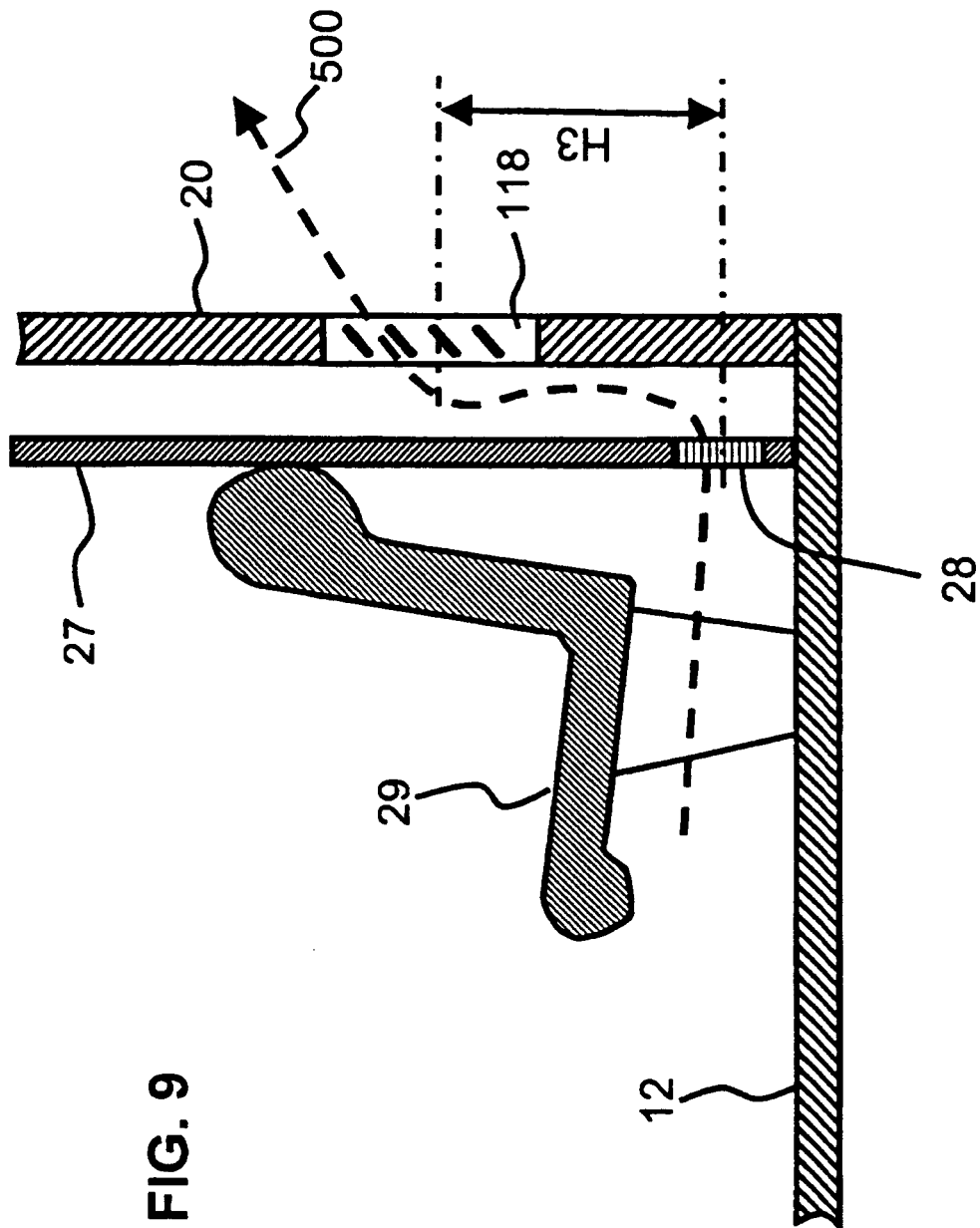
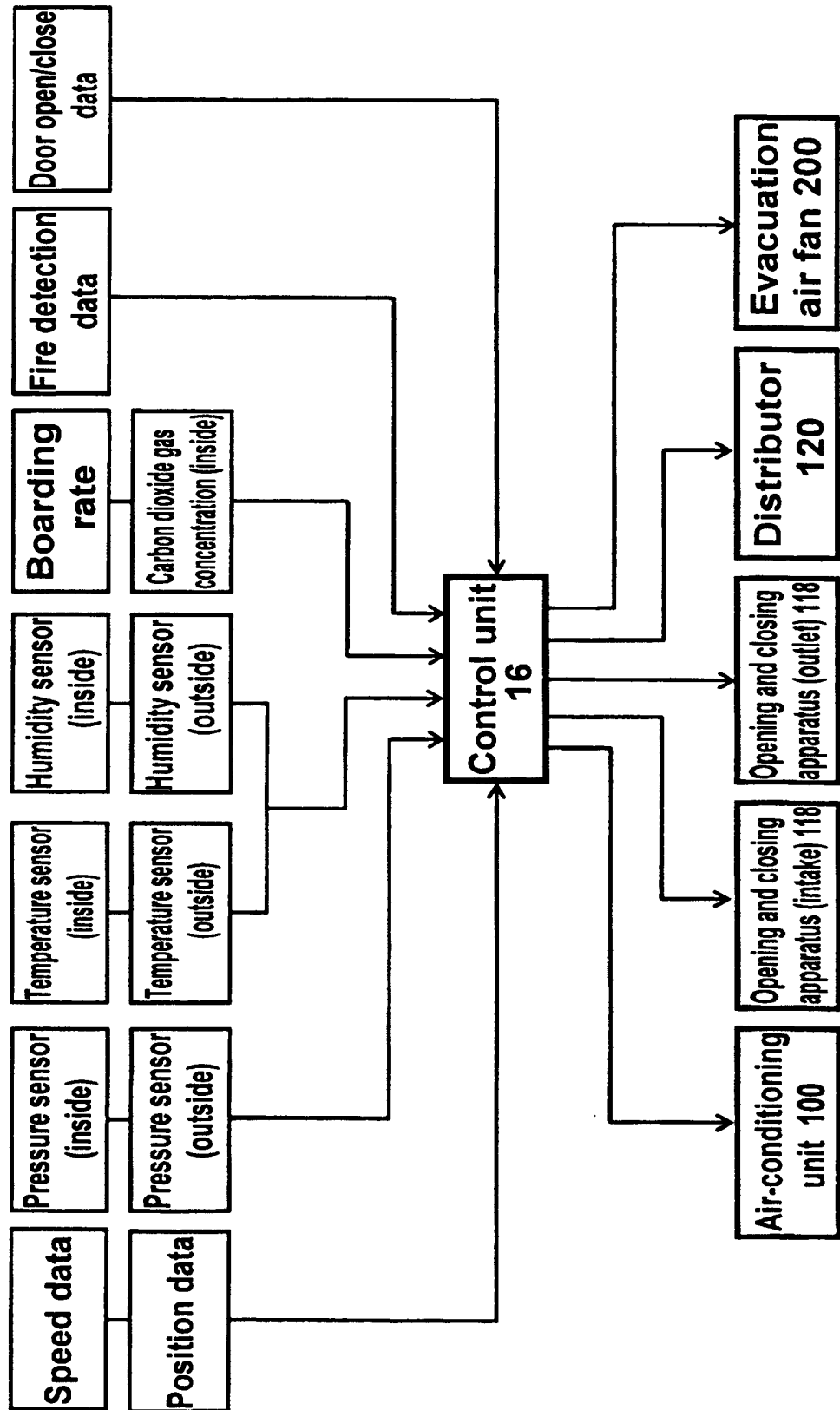
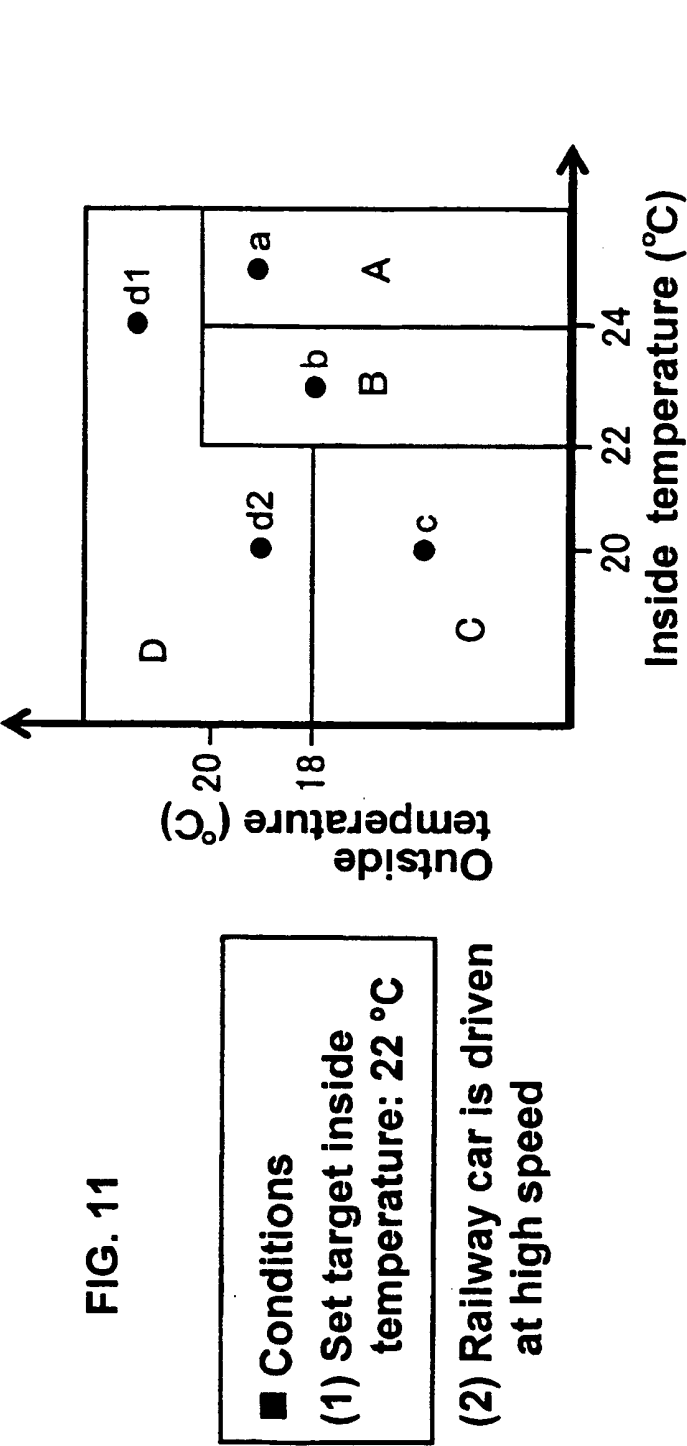


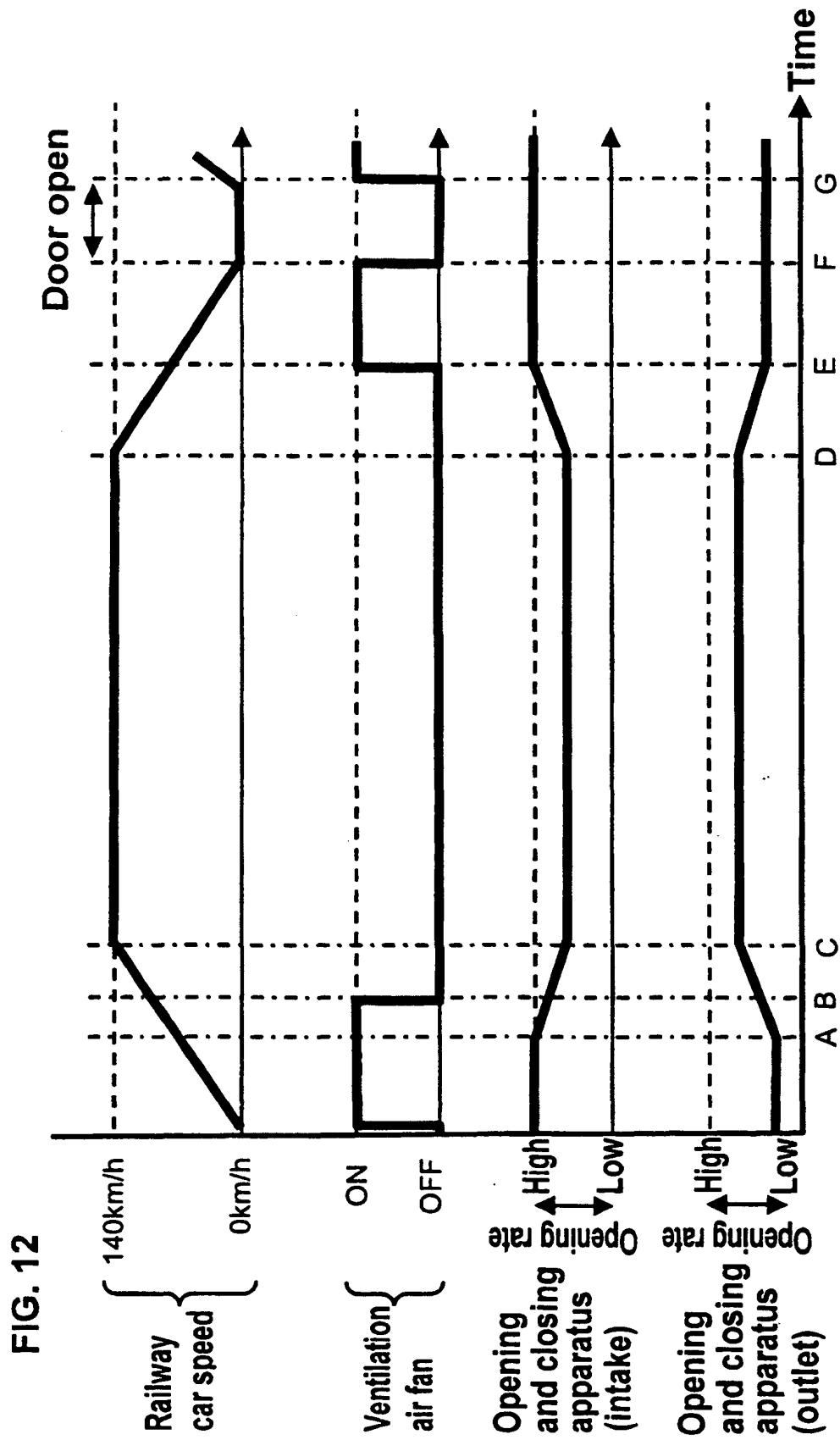
FIG. 9

FIG. 10





Area	Air-conditioning unit 100	Opening and closing apparatus 118 (Intake -side opening rate)	Opening and closing apparatus 118 (Outlet -side opening rate)	Evacuation air fan 200
A	Cooling	High	High	ON
B	Stopped	High	High	OFF or ON
C	Heating	Low	Low	OFF
D	Cooling or Heating	Low	Low	OFF
During fire	Stopped	Low	Low	ON



REFERENCES CITED IN THE DESCRIPTION

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