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(54) **Railway car**

Eisenbahnwaggon

Wagon de train

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Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to a railway car having an air conditioner disposed on a rooftop of the car for supplying conditioned air into a cabin or for ventilating the cabin.

Description of the related art

[0002] Conventionally, air conditioners for air-conditioning re-circulated air from the cabin and supplying the conditioned air into the cabin or also equipped with a ventilating function for discharging the air within the cabin to the exterior and introducing fresh outside air into the cabin are mainly disposed above roof structures of railway cars. Fig. 10 is a cross-sectional view cut along a longitudinal direction 520 of the railway car showing a roof structure equipped with an air conditioner disposed above the roof structure and said air conditioner. According to Fig. 10, the air conditioner disposed above a roof structure 40 constituting the railway car has partitions disposed in the interior of a casing thereof to define an exterior blower chamber 102, an indoor blower chamber 104 and an equipment chamber 106. A heat insulating material 42 is applied on the inner side of the car of the roof structure 40, so as to prevent heat from the outer side of the car from entering the inner side of the car (especially in summer) and prevent heat from the inner side of the car from escaping to the outer side of the car (especially in winter).

[0003] An opening is formed at a portion of the lower wall of the indoor blower chamber 104 facing the roof structure 40, and an opening 41 is formed on the roof structure 40 corresponding to said opening. An airtight packing is disposed around the opening 41 between the roof structure 40 and the air conditioner 100, so as to prevent rain water and dust from entering the car and separating outer air and air-conditioned air. A vertical ventilation duct 43 is disposed on the opening 41 between the roof structure 40 and the ceiling 47 of the car.

[0004] A porous plate 48 and a filter 46 are layered in the named order from the side facing the cabin and disposed on the opening of the ceiling 47 connected to the ventilation duct 43. The porous plate 48 and the ceiling 47 substantially constitute an identical plane. An end in a height direction 530 (refer to Fig. 1) of the ventilation duct 43 is connected to the opening 41 formed on the roof structure 40. As shown by the air flow 300, the air within the cabin passes through the porous plate 48 and the filter 46 and via the ventilation duct 43 to be introduced into the indoor blower chamber 104. Although not shown, an indoor blower and an indoor heat exchanger are disposed within the indoor blower chamber 104, and the temperature and humidity of the air guided from the cabin

into the indoor blower chamber 104 is conditioned while passing through the indoor heat exchanger, and then re-supplied as conditioned air from the indoor blower chamber 104 into the cabin of the railway car.

[0005] When a railway car having the air conditioner mounted on the rooftop thereof is driven at high speed, air cannot flow smoothly around the air conditioner and air flow separation occurs for example from the front edge of the air conditioner. The separated air flow creates a flow in which swirling in alternating directions are formed continuously, such as a Karman vortex, applying a periodic aerodynamic vibration force on the upper cover of the rooftop equipment and causing the upper cover to vibrate. The vibration of the outer wall causes noise 310 to be generated within the air conditioner, and the noise 310 is transmitted through the opening formed on the ceiling of the cabin directly into the cabin. Such noise has a prominent peak at frequency f1 corresponding to a characteristic value of the upper cover constituting the indoor blower chamber 104, as shown by the dotted line of Fig. 9.

[0006] Japanese patent application laid-open publication No. 2002-347617 (Patent document 1) teaches a railway car having an indoor blower of an air conditioner mounted in a space between the roof structure and the ceiling of the railway car and having cold air blown straight in the longitudinal direction of the car body, so that the ventilation resistance of the blowout section of the indoor blower is reduced to enhance the flow of cold air, and a small-sized air blower having an impeller whose outer diameter is smaller than that of a conventional impeller is used, by which the noise within the car can be reduced and power consumption of the indoor blower can be reduced.

[0007] Further, Japanese patent application laid-open publication No. 2007-253693 (patent document 2) discloses an air conditioner for a vehicle and a railway car equipped therewith, wherein the air conditioner (body) mounted on the rooftop of a railway car has built therein indoor blowers for blowing air into the cabin and guide plates disposed under the blowers for changing the direction of flow of the air blown from the blowers, wherein the vibration generated when the air blown from the blowers collide against the guide plates is prevented from being directly transmitted to the car body, so as to suppress the vibration generated when the air blown from the blowers collide against the guide plates and reduce the vibration transmitted to the car body.

[0008] The noise within the cabin of the car is one of the causes that deteriorate the pleasantness of passengers. Therefore, the pleasantness of passengers may be deteriorated by the noise 310 generated by the air conditioner being transmitted to the cabin through the opening on the ceiling 47 of the cabin and diffused within the cabin as shown in Fig. 10.

[0009] The problem to be solved according to the present invention is to devise the arrangement of a ventilation duct connecting the rooftop equipment mounted

on the roof structure of the railway car and the cabin, to thereby attenuate the noise entering the ventilation duct from the air conditioner in the process of traveling through the ventilation duct into the cabin.

SUMMARY OF THE INVENTION

[0010] The present invention aims at solving the problems of the prior art by providing a railway car capable of maintaining the pleasantness of passengers by attenuating the noise entering the cabin of the railway car even when noise caused by the aerodynamic vibration of the air conditioner, especially the upper cover thereof, enters the ventilation duct.

[0011] First and second aspects of the present invention provide railway cars according to claims 1 and 3.

[0012] According to the present railway car, if noise is generated by aerodynamic operation caused by the flow of outer air in the air conditioner mounted above the roof structure and the noise enters the duct that forms a flow path of air to the air conditioner, since the duct is designed so that the difference between a distance in a horizontal direction from the first opening to one of the second openings and a distance in a horizontal direction from the first opening to the other second opening is substantially equal to the length having added to an integral multiple of a wavelength corresponding to a peak frequency of the noise generated from the air conditioner a half wavelength thereof, the noise transmitted through the first opening and the second openings into the cabin can be deadened within the cabin at equal distances from the openings due to mutual interference. According to the present railway car, the two second openings may not be aligned with the first opening in a height direction of the railway car, and can be offset in a longitudinal direction or a width direction of the railway car.

[0013] In any of the above-mentioned railway cars, a porous plate can be disposed on the second opening on a side facing the cabin, and a local aperture ratio of an area of the porous plate close to the first opening can be set low and a local aperture ratio of an area of the porous plate far from the first opening can be set high. Further according to any of the above-mentioned railway cars, the duct can have a sound absorbing function provided on the flow path side thereof, and the sound absorbing function can be provided by adopting at least one of the following arrangements: forming the panel member constituting the duct using a porous sound absorbing panel member; attaching a sound absorbing panel member to the panel member constituting the duct; and disposing a sound absorbing rectifying member on the panel member constituting the duct for smoothing the flow of air passing through the flow path. Furthermore, the duct constituting an expansion-chamber silencer or an interference silencer can be arranged so that one duct is disposed on a center in the width direction of the railway car or two ducts are disposed on either side in the width direction of the railway car. Even further, the present railway car arrange-

ment can be applied to a ventilation unit having a ventilation function of the air within the cabin in place of the air conditioner, or to an air conditioner equipped with the ventilation function of the air within the cabin.

[0014] The present invention can provide a railway car capable of overcoming the deterioration of pleasantness of passengers caused by the noise generated in the air conditioner, by adopting a ventilation duct connecting the roof structure having the air conditioner mounted thereon and the ceiling portion of the cabin constituting an interference silencer so that the noise passing therethrough is deadened via mutual interference within the cabin at equal distances from the openings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a perspective view illustrating a railway car equipped with an air conditioner;

Fig. 2 is a cross-sectional view showing arrangement 1 of the railway car cut at perpendicular cross-section A along the longitudinal direction of the railway car shown in Fig. 1, not forming part of the invention;

Fig. 3 is a cross-sectional view showing arrangement 2 of the railway car cut at perpendicular cross-section A along the longitudinal direction of the railway car shown in Fig. 1, not forming part of the invention;

Fig. 4 is a cross-sectional view showing arrangement 3 of the railway car cut at perpendicular cross-section A along the longitudinal direction of the railway car shown in Fig. 1 not forming part of the invention;

Fig. 5 is a cross-sectional view showing embodiment 1 of the railway car according to the present invention cut at perpendicular cross-section A along the longitudinal direction of the railway car shown in Fig. 1; Fig. 6 is a cross-sectional view showing embodiment 2 of the railway car according to the present invention cut at perpendicular cross-section B along the width direction of the railway car shown in Fig. 1;

Fig. 7 is a cross-sectional view showing embodiment 3 of the railway car according to the present invention cut at perpendicular cross-section B along the width direction of the railway car shown in Fig. 1;

Fig. 8 is a view showing embodiment 4 of the railway car according to the present invention, showing a ceiling of a cabin of the railway car seen from arrow view C-C of Figs. 4 and 5;

Fig. 9 is a frame format view comprising the frequency characteristics of the noise level within the cabin when the prior art railway car having an air conditioner mounted on the rooftop is driven at high speed and that of the present invention; and

Fig. 10 is a cross-sectional view of a prior art railway car having an air conditioner mounted on the rooftop thereof cut along the longitudinal direction of the railway car (corresponding to cross-section A of Fig. 1).

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Now, arrangements and preferred embodiments of a railway car equipped with a rooftop equipment will be described with reference to the drawings.

[Arrangement 1]

[0017] Fig. 1 is a perspective view showing a railway car equipped with an air conditioner. As shown in Fig. 1, a width direction of a railway car (hereinafter simply referred to as "car") is denoted by number 510, and the longitudinal direction and the height direction of the car orthogonal to 510 are denoted by numbers 520 and 530. A car 1 is composed of an underframe 10 constituting a floor portion thereof, side structures 20 and 20 (only one of which is shown) erected from both ends in the width direction 510 of the underframe 10, end structures 30 and 30 (only one of which is shown) erected from both ends in the longitudinal direction 520 of the underframe 10, and a roof structure 40 mounted on the upper ends in the height direction 530 of the side structures 20 and 20 and the end structures 30 and 30.

[0018] In order to realize both lighter weight and improved productivity of the car, a method has been established to form the underframe 10, the side structures 20 and the roof structure 40 using hollow extruded shape members formed of aluminum alloy in which two opposing face plates are connected 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.

[0019] 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. Doors 24 enabling passengers to board and alight the railway car and windows 22 are disposed on the side structures 20 constituting the railway car 1. Air conditioners 100 and 100 are mounted on the upper side of the roof structure 40, which are secured to position via appropriate fixing means.

[0020] Fig. 2 shows a first arrangement of a railway car, which is a cross-sectional view of the railway car cut at a perpendicular cross-section A along the longitudinal direction shown in Fig. 1. The components and sections equivalent to those of the prior art car illustrated in Fig. 10 are denoted by the same reference numbers and detailed descriptions thereof are omitted. As shown in Fig.

2, a ceiling member 47 defining a ceiling of a cabin (hereinafter simply referred to as "ceiling") is disposed on a lower side of the roof structure 40 facing the cabin at a distance from the roof structure 40. The roof structure 40 has an opening 41 as a first opening formed to enable air to flow to the air conditioner 100. Further, an opening 47a as a second opening is disposed on the ceiling 47 enabling air from the cabin to pass therethrough. In the present embodiment, the opening 47a is disposed substantially immediately below the opening 41. A ventilation duct 43 is disposed between the roof structure 40 and the ceiling 47 so as to connect the opening 41 formed on the roof structure 40 and the opening 47a formed on the ceiling 47. The ventilation duct 43 connects the opening 41 and the opening 47a to constitute a flow path communicating the opening 41 and the opening 47a, so as to allow the air within the cabin to flow into the air conditioner 100.

[0021] The ventilation duct 43 is formed so that the dimension thereof in the longitudinal direction 520 of the car is greater than the ventilation duct 43 illustrated in Fig. 10. In other words, since the cross-sectional area of the ventilation duct 43 is designed to be greater than the opening area of the opening 41, the ventilation duct 43 constitutes an expansion-chamber silencer. A filter 46 and a porous plate 48 are attached to the opening 47a of the ceiling 47. The opening 47a disposed on the ceiling 47 is not aligned with the opening 41 formed on the roof structure 40 in the height direction 530 of the car 1, and is formed at an offset position in the longitudinal direction 520. A panel member constituting the ventilation duct 43 and a panel member constituting the ceiling 47 are disposed immediately below the opening 41 of the roof structure 40. Normally, the panel member constituting the ventilation duct 43 is provided with a sound absorbing function by forming the panel member itself using porous members, or either in place of or in addition to this sound absorbing function, as shown in Fig. 2, a sound absorbing member 45 is attached to the side facing the air flow path of the panel member constituting the ventilation duct 43 to enhance the sound deadening function of the ventilation duct 43.

[0022] According to the above-described arrangement, the air from the cabin is flown as shown by the arrow 300 through the opening 47a formed on the ceiling 47 equipped with the filter 46 and the porous plate 48 into the ventilation duct 43 and then flown in a bent manner toward the opening 41 formed on the roof structure 40.

[0023] When the car 1 is driven at high speed, noise 310 is generated by the aerodynamic vibration of an upper cover of the air conditioners caused by the air flow separation on the outer side of the air conditioners 100 disposed as rooftop equipments. Noise 310 normally travels through the opening 41 and the inner side of the ventilation duct 43 and passes through the opening 47a equipped with the filter 46 and the porous plate 48 into the cabin and is diffused (radiated) into the cabin. In em-

bodiment 1, even if the noise 310 is emitted toward the cabin, the noise is prevented from directly travelling into the cabin by the ceiling 47 of the cabin disposed immediately below the opening 41 of the roof structure 40 and the bottom plate of the ventilation duct 43 disposed along the upper surface of the ceiling 47, and the noise is insulated. Further, the expansion-chamber silencer formed by the ventilation duct 43 enables to reduce the noise level of the noise 310. Moreover, the noise 310 is attenuated or absorbed while traveling within the ventilation duct 17 by the interference effect in which the direction of travel of the noise is bent and by the sound absorbing effect of the plate-shaped sound absorbing member 45 having a sound absorbing performance attached to the panel member constituting the ventilation duct 17, by which the noise level is reduced.

[0024] The present arrangement is adopted in a railway car equipped with a rooftop equipment having a function to perform air conditioning of the air within the cabin, but the present arrangement can also be applied to a railway car having a ventilation duct connected to an opening for taking in air from the cabin to a ventilation unit for ventilating the air within the cabin or a ventilation unit chamber of an air conditioner having a ventilation unit built therein. Further, the present arrangement can be disposed on a cross-sectional position in a perpendicular plane extending in the longitudinal direction of the railway car in which the opening of the ceiling of the cabin is disposed at the center of the car. In this case, by arranging the opening of the roof structure 40 and the opening of the ceiling of the cabin to be displaced in the longitudinal direction of the car, the direction of travel of the noise traveling through the ventilation duct is bent.

[0025] Fig. 9 shows an outline of the noise characteristics of the frequency and the sound pressure level within the cabin of the railway car according to the present invention. According to the present invention, the sound pressure level can be reduced in the entire frequency band including a frequency f_1 in which the sound pressure level is specifically high.

[0026] According to arrangement 1 shown in Fig. 2, a sound absorbing member (rectifying member) 45 having a triangular cross-section with an inclined plane is disposed so as not to block the air flow 300 within the ventilation duct 43 at a bent section (corner section) of the duct where stagnation or swirling of the air flow 300 is likely to occur. The sound absorbing member (rectifying member) 45 not only exerts a sound absorbing effect but also suppresses the increase of pressure loss of the ventilation duct 43. Thus, the air flow 300 within the ventilation duct 43 can be made smooth and the noise colliding against the ceiling 47 of the cabin can be absorbed. The sound absorbing member (rectifying member) 45 can also be disposed at a bent section at the opposing corner from the illustrated arrangement position of the sound absorbing member (rectifying member) 45 within the ventilation duct 43. Further, if the ventilation duct 43 alone enables to realize a sufficient noise reducing effect, the

sound absorbing member (rectifying member) 45 can be omitted.

[Arrangement 2]

[0027] Fig. 3 is a view showing a second arrangement of the railway car, which is a cross-sectional view taken at perpendicular cross-section A along the longitudinal direction of the railway car illustrated in Fig. 1. The components equivalent to those in the arrangement shown in Fig. 2 are denoted by the same reference numbers and the detailed descriptions thereof are omitted. In arrangement 2 of Fig. 3, openings 44a and 44b are formed on the ventilation duct 43 corresponding to the opening 41 formed on the roof structure 40 and the opening 47a formed on the ceiling 47. The opening 41 of the roof structure 40, the openings 44a and 44b of the ventilation duct 43 and the opening 47a of the ceiling 47 are all formed along a substantially common center axis.

[0028] The cross-sectional area 70 of the ventilation duct 43 perpendicular to the air flow 300 (horizontal plane) is greater than the area of the opening 44b of the ventilation duct 43, so that the ventilation duct 43 constitutes an expansion-chamber silencer. The transmission loss of the expansion-chamber silencer defined by the ventilation duct 43 is dominated by the ratio of the area of the opening 41 and the cross-sectional area 70, so that the cross-sectional area 70 of the ventilation duct 43 should be selected so that the transmission loss of the prominent frequency f that needs to be deadened becomes high. Further, the spreading of the cavity of the ventilation duct 43 in the left and right (lateral) directions may be symmetric or asymmetric. Although not shown, as illustrated in Fig. 2, a plate-like sound absorbing member 45 can be attached to the surface of the panel member forming the ventilation duct 43. The ventilation duct 43 having a cross-sectional area 70 selected so that the transmission loss of the peak frequency f_1 of the noise becomes high enables to effectively attenuate the peak frequency f_1 of the noise caused by the upper cover of the air conditioner 100, so that the noise level emitted into the cabin through the opening 47a of the ceiling 47 can be suppressed.

[0029] Further according to the present arrangement, the air flow 300 is substantially not bent in the ventilation duct 43, so that the pressure loss can be minimized compared to other embodiments. Therefore, the static pressure of the specification demanded in an indoor blower disposed in the interior of the air conditioner 100 can be reduced, so that the consumption power can be cut down and the noise level generated from the indoor blower itself can also be reduced.

[Arrangement 3]

[0030] Fig. 4 is a view showing a third arrangement of the railway car, showing a cross-sectional view in which the railway car shown in Fig. 1 is cut at a perpendicular

cross-section A along the longitudinal direction. The components and sections equivalent to those in the structure illustrated in Fig. 2 are denoted by the same reference numbers and detailed descriptions thereof are omitted. According to arrangement 3 as illustrated in Fig. 4, the number of the opening 41 formed on the roof structure 40 is one but the opening on the ceiling 47 is divided into multiple parts. In the illustrated example, two openings 47a and 47a are disposed in dispersed manner along the longitudinal direction 520 of the car 1. The ventilation duct 43 also has openings 44a; 44b and 44b corresponding to these openings 47a and 47a formed thereto.

[0031] A bottom panel is extended to the portion of the ventilation duct 43 opposed to the opening 41 formed on the roof structure 40, so that the opening 41 is not visible from immediately below the opening within the cabin. Further, on the upper surface of a bottom panel at a branch point of the ventilation duct 43 opposed to the opening 41 is disposed a sound absorbing member (rectifying member) 45. The sound absorbing member (rectifying member) 45 has a substantially triangular cross-sectional shape and arranged so that both sides thereof constitute equally inclined planes. A filter 46 and a porous plate 48 are arranged respectively on the openings 47a and 47a of the ceiling 47 and the openings 44b and 44b of the ventilation duct 43. Although not shown, as shown in Fig. 2, a plate-shaped sound absorbing member 45 can be adhered to the surface of a panel member of the ventilation duct 43 as shown in Fig. 2.

[0032] According to the above-described arrangement, the air from the cabin enters through two openings 47a and 47a formed on the ceiling 47 and passes through the porous plates 48 and the filters 46 as air flows 300 and 300 into the ventilation duct 43. The air flows 300 and 300 in the ventilation duct 43 are guided smoothly via a triangular sound absorbing member (rectifying member) 45 so that the increase of pressure loss in the ventilation duct 43 is suppressed. The air flows 300 and 300 are converged near the opening 41 of the roof structure 40 to flow into the indoor blower chamber 104. The noise 310 generated in the indoor blower chamber 104 travels into the ventilation duct 43 through the opening 41 on the roof structure 40, but it is insulated by the panel member (bottom panel) constituting the ventilation duct 43. Further, the noise 310 collides against the sound absorbing member 45 arranged on the air flow side of the panel member of the ventilation duct 43 and is absorbed or suppressed before being diffused into the cabin. Moreover, the noise 310 travels in a bent manner within the ventilation duct 43 and further attenuated, so that the traveling of noise into the cabin through the openings 47a and 47a on the ceiling 47 can even further be reduced.

[0033] According to the arrangement, multiple openings 47a and 47a are disposed on the ceiling 47 of the cabin, so that the opening areas of the respective openings 47a formed on the ceiling 47 can be reduced to ensure an equivalent amount of air flow as the air flow 300 within the cabin flowing through the arrangement shown

in Fig. 2. Therefore, since the present arrangement enables to enhance the reflection of noise by the openings 47a formed on the ceiling 47, the noise within the cabin can be reduced even further than the arrangement of Fig. 2. Further, the number of openings 47a disposed on the ceiling 47 can be three or more. Furthermore, the sound absorbing member 45 can be omitted if sufficient noise reduction effect is achieved without the member.

10 [Embodiment 1]

[0034] Fig. 5 illustrates a first embodiment of the railway car according to the present invention, showing a cross-sectional view in which the railway car shown in Fig. 1 is cut at a perpendicular cross-section A along the longitudinal direction. The components and sections equivalent to the structure illustrated in Fig. 2 are denoted by the same reference numbers and detailed descriptions thereof are omitted. Embodiment 1 illustrated in Fig. 5 has a basic arrangement similar to the arrangement of arrangement 3 shown in Fig. 4, but the distances L1 and L2 from the center of the opening 41 formed on the roof structure 40 to the center of the openings 47a and 47a formed on the ceiling differ. Further, the triangular sound absorbing member (rectifying member) 45 illustrated in Fig. 4 is not shown in Fig. 5, but it can be disposed if necessary.

[0035] The difference between distances L1 and L2 (= L1-L2) is substantially equal to the value having added to an integral multiple of the wavelength corresponding to the peak frequency f1 of the noise shown in Fig. 10 a half wavelength $\lambda/2$ thereof, wherein by disposing openings 47a and 47a having a difference between distances L1 and L2, the ventilation duct 43 is formed as an interference silencer. Therefore, regarding the peak frequency f1 of the noise, the noises emitted from the respective openings 47a and 47a formed on the ceiling 47 are deadened via interference within the cabin at equal distances from the openings 47a and 47a, so that the noise having a prominent peak frequency is reduced in the cabin and the pleasantness within the cabin can be improved.

[Embodiment 2]

[0036] Fig. 6 is a view illustrating embodiment 2 of the railway car according to the present invention, which is a cross-sectional view taken at perpendicular cross-section B along the width direction of the railway car shown in Fig. 1. The components and sections equivalent to the structure illustrated in Fig. 2 are denoted by the same reference numbers and detailed descriptions thereof are omitted. In embodiment 2, heat exchangers 112 and 112 are arranged in separated manner along the width direction 510 of the car within the indoor blower chamber 104 constituting the air conditioner 100, and a blower 110 is disposed at the center in the width direction 510 between both heat exchangers 112 and 112. Ventilation ducts 43 (ducts are not shown in the drawing) adopting an arrange-

ment in which openings are arranged in a dispersed manner similar to the ventilation duct 43 shown in Fig. 5 are disposed on left and right sides in the width direction 510 between the roof structure 40 and the ceiling 47 disposed on the inner side thereof.

[0037] As shown in the right side of Fig. 6, the ceiling 47 has openings 47a and 47a formed in a dispersed manner at positions separated from each other in the width direction 510. Each opening 47a has a filter 46 attached thereto. The openings 47a and 47a are arranged so that the distances from the center of the opening 41 of the roof structure 40 to the centers of openings 47a and 47a differ, as shown by L3 and L4. Openings 47b and 47b are disposed at the center in the width direction 510 of the ceiling 47. The conditioned air blown out of the blower 110 flows through the openings disposed at the center of width 510 of the roof structure 40 and is blown into the cabin through the openings 47b and 47b formed on the ceiling 47.

[0038] Since the openings 47a and 47a disposed on the ceiling 47 are formed at different distances (L3 and L4) from the opening 41 of the roof structure 40, an interference silencer is constituted, according to which the noise 310 generated in the indoor blower chamber 104 and emitted through openings 47a and 47a is deadened via interference within the cabin at equal distances from the openings 47a and 47a. As described, the arrangement of the openings 47a on the ceiling 47 of the cabin can be determined arbitrary with respect to the lateral direction 510 and the longitudinal direction 520 of the car, and the number of openings 47a on the ceiling 47 can also be determined arbitrarily. Therefore, regarding the peak frequency f_1 of noise, the noises emitted through respective openings 47a and 47a on the ceiling 47 can be deadened via interference within the cabin at equal distances from the openings, according to which the noise having a prominent peak frequency can be reduced in the cabin and the pleasantness within the cabin can be improved.

Embodiment 3]

[0039] Fig. 7 illustrates a third embodiment, of the railway car according to the present invention, showing a cross-sectional view in which the railway car shown in Fig. 1 is cut at a perpendicular cross-section B along the width direction of the railway car. The components and sections equivalent to those in the structure illustrated in Fig. 6 are denoted by the same reference numbers and detailed descriptions thereof are omitted. In embodiment 3, the ventilation duct arrangement disposed on left and right sides in the width direction 510 of the car is not illustrated, but as shown in Fig. 5, an arrangement is adopted in which the openings 47a and 47a on the ceiling 47 are arranged in dispersed manner along the longitudinal direction 520 of the car and the distances from the center of the opening 41 formed on the roof structure 40 to the center of the openings 47a and 47a are varied as

shown by L1 and L2, and the difference between the distances ($= L1 - L2$) is substantially equal to the value having added to an integral multiple of the wavelength corresponding to the peak frequency f_1 of the noise shown in Fig. 10 a half wavelength $\lambda/2$ thereof.

[0040] The noise generated in the indoor blower chamber 104 of the air conditioner 100 is emitted into the cabin through the openings 47a and 47a arranged in a dispersed manner along the width direction 510 on the ceiling 47. The phases of noise 310 emitted through the openings 47a and 47a into the cabin are set so that the phases become opposite at positions close to the ears of standing passengers at substantially equal distances from the openings 47a and 47a (position at distance H1 from the floor surface of the underframe 10) and positions close to the ears of sitting passengers at predetermined distances from the openings 47a and 47a (position at distance H2 from the floor surface of the underframe 10).

[0041] As described, since the phases of noises 310 emitted from openings 47a and 47a formed on the ceiling 47 are opposite, the noise at areas close to the ears of passengers sitting or standing in the cabin can be deadened via interference, according to which the noise having a prominent peak frequency can be reduced in the cabin and the pleasantness within the cabin can be improved.

[Embodiment 4]

[0042] Fig. 8 shows a fourth embodiment of the railway car according to the present invention, which is a view of a ceiling of the cabin of the railway car seen from the direction of arrows C-C in Figs. 4 and 5. In the present embodiment, as shown in Fig. 8, the panel member of the ceiling 47 is disposed immediately below the opening 41 formed on the roof structure 40, and the area below the opening 41 is covered by the ceiling 47.

[0043] In the present embodiment, porous plates 48 are fit to the openings 47a formed on the ceiling 47 of the cabin. The distances P1, P2, P3 ... between the pores 49 of the porous plate 48 are designed to become shorter as the distances from the opening 41 of the roof structure 40 to the pores 49 increase (inversely proportional). In other words, the interval is set short in the area where the distance from the opening 41 (sound source) is long (so that the aperture ratio of local porous plates 48 becomes high) and the interval is set long in the area where the distance from the opening is short (so that the aperture ratio of local porous plates 48 becomes small). According to this arrangement, the travel distance of the noise traveling through the ventilation duct 43 (Figs. 4 and 5) and emitted through the porous plates 48 on the openings 47a formed on the ceiling 47 of the cabin is elongated (since greater amount of air flow 300 is allowed to pass through areas where travel distance becomes longer by reducing the interval between pores), so that the noise can be attenuated by distance, and the sound insulation property of the porous plate 48 is enhanced

by reducing the aperture ratio of the porous plate 48 at areas close to the sound source and increasing the aperture ratio at areas distant from the sound source. The arrangement of the ventilation duct according to the present embodiment can be applied to arrangement 1 shown in Fig. 2.

[0044] Thus, the noise caused in the air conditioner 100 traveling through the ventilation duct 43 and emitted via the openings 49 of the porous plates 48 into the cabin can be attenuated both by the distance attenuation effect and the sound insulation effect of the porous plates 48, so that the noise level in the cabin can be reduced and the pleasantness within the cabin can be improved.

[0045] The arrangement according to the present embodiment is adopted in a railway car having an air conditioner 100 disposed on the rooftop having a function to perform air conditioning of the air within the cabin, but the present arrangement can also be adopted in a railway car having an evacuation unit (ventilation unit) disposed on the rooftop for discharging the air within the cabin to the exterior. In that case, the opening disposed on the predetermined position on the roof structure 40 constituting the railway car 1 and the opening disposed on the ceiling within the cabin are connected via a ventilation duct, wherein the arrangements disclosed in arrangements 1 through 3 and embodiments 1, 2 and 4 can be adopted in the ventilation duct and the porous plates attached to the openings of the ceiling, according to which the noises caused by the upper cover of the evacuation unit traveling into the cabin can be suppressed.

Claims

1. A railway car (1) comprising:

a roof structure (40) having an air conditioner (100) disposed on an upper portion thereof and having a first opening (41) enabling air to flow to the air conditioner;
a ceiling member disposed on a lower side of the roof structure to define a ceiling (47) of a cabin and having two second openings (47a) enabling air to pass through from the cabin; and
a duct (43) connecting the first opening (41) and the second openings (47a) for constituting a flow path communicating the first opening (41) and the second openings (47a);

characterized in that a difference between a distance (L1) in a horizontal direction from the first opening (41) to one of the second openings (47a) and a distance (L2) in a horizontal direction from the first opening (41) to the other second opening (47a) is set substantially equal to a length having added to an integral multiple of a wavelength corresponding to a peak frequency of the noise generated from the air conditioner a half wavelength thereof, so that the

duct constitutes an interference silencer.

2. The railway car according to claim 1, wherein the air conditioner is equipped with an evacuation unit for discharging the air within the cabin to the exterior.

3. A railway car comprising:

a roof structure having an evacuation unit disposed on an upper portion thereof for discharging air within a cabin to the exterior and having a first opening (41) enabling air to flow to the evacuation unit;
a ceiling member disposed on a lower side of the roof structure to define a ceiling (47) of the cabin and having two second openings (47a) enabling air to pass through from the cabin; and
a duct (43) connecting the first opening (41) and the second openings (47a) for constituting a flow path communicating the first opening (41) and the second openings (47a);

characterized in that a difference between a distance in a horizontal direction from the first opening (41) to one of the second openings (47a) and a distance in a horizontal direction from the first opening (41) to the other second opening (47a) is set substantially equal to a length having added to an integral multiple of a wavelength corresponding to a peak frequency of the noise generated from the evacuation unit a half wavelength thereof, so that the duct constitutes an interference silencer.

4. The railway car according to any one of the previous claims, wherein
in order to prevent noise generated in the air conditioner from being transmitted directly from the first opening (41) to the second openings (47a), a panel member constituting the duct or a panel member constituting the duct layered on a panel member constituting the ceiling member disposed on the cabin side is arranged substantially immediately below the first opening.

5. The railway car according to any one of the previous claims, wherein
the two second openings (47a) are not aligned with the first opening (41) in a height direction (530) of the railway car, and are offset in a longitudinal direction (520) or a width direction (510) of the railway car.

6. The railway car according to any one of claims 1 through 5, wherein
a respective porous plate (48) is disposed on each second opening (47a) on a side facing the cabin; and
a local aperture ratio of an area of each porous plate (48) close to the first opening (41) is set low and a local aperture ratio of an area of the porous plate

(48) far from the first opening (41) is set high.

7. The railway car according to any one of claims 1 through 6, wherein
the duct (43) has a sound absorbing function provided on the flow path side thereof; and
the sound absorbing function is provided by adopting at least one of the following arrangements: forming the panel member constituting the duct using a porous sound absorbing panel member; attaching a sound absorbing panel member to the panel member constituting the duct; and disposing a sound absorbing rectifying member on the panel member constituting the duct for smoothing the flow of air passing through the flow path.
8. The railway car according to any one of claims 1 through 7, wherein
the duct (43) constituting an interference silencer is arranged so that one duct is disposed at a center in the width direction of the railway car or two ducts are disposed on either side in the width direction of the railway car.

Patentansprüche

1. Eisenbahnwaggon (1), umfassend:

eine Dachstruktur (40) mit einer an ihren oberen Teil angebrachten Klimaanlage (100) und mit einer ersten Öffnung (41), die ein Strömen von Luft zur Klimaanlage ermöglicht;
ein Deckenelement, das an einer unteren Seite der Dachstruktur angeordnet ist, um eine Decke (47) einer Kabine zu definieren, und das zwei zweite Öffnungen (47a) aufweist, die ein Durchströmen von Luft aus der Kabine ermöglichen; und
einen Schacht (43), der die erste Öffnung (41) und die zweiten Öffnungen (47a) verbindet, um einen Strömungspfad zu bilden, der die erste Öffnung (41) und die zweiten Öffnungen (47a) verbindet;

dadurch gekennzeichnet, dass eine Differenz zwischen einem Abstand (L1) in einer horizontalen Richtung von der ersten Öffnung (41) zu einer der zweiten Öffnungen (47a) und einem Abstand (L2) in einer horizontalen Richtung von der ersten Öffnung (41) zu der anderen zweiten Öffnung (47a) so eingestellt ist, dass sie im Wesentlichen einer Länge gleicht, bei der zu einem ganzzahligen Vielfachen einer Wellenlänge, die einer Spitzenfrequenz des von der Klimaanlage erzeugten Rauschens entspricht, eine halbe Wellenlänge davon hinzuaddiert wurde, sodass der Schacht einen Interferenzdämpfer bildet.

2. Eisenbahnwaggon nach Anspruch 1, wobei die Klimaanlage mit einer Ablufteinheit ausgestattet ist, um die Luft innerhalb der Kabine nach außen abzugeben.

3. Eisenbahnwaggon, umfassend:

eine Dachstruktur, die eine Ablufteinheit, die an deren oberen Teil angeordnet ist, um Luft innerhalb einer Kabine nach außen abzugeben, und eine erste Öffnung (41) aufweist, die ein Strömen von Luft zur Ablufteinheit ermöglicht;
ein Deckenelement, das an einer unteren Seite der Dachstruktur angeordnet ist, um eine Decke (47) der Kabine zu definieren, und das zwei zweite Öffnungen (47a) aufweist, die ein Eintreten von Luft aus der Kabine ermöglichen; und
einen Schacht (43), der die erste Öffnung (41) und die zweiten Öffnungen (47a) verbindet, um einen Strömungspfad zu erzeugen, der die erste Öffnung (41) und die zweiten Öffnungen (47a) verbindet;

dadurch gekennzeichnet, dass eine Differenz zwischen einem Abstand in einer horizontalen Richtung von der ersten Öffnung (41) zu einer der zweiten Öffnungen (47a) und einem Abstand in einer horizontalen Richtung von der ersten Öffnung (41) zu der anderen zweiten Öffnung (47a) so eingestellt ist, dass sie im Wesentlichen einer Länge gleicht, bei der zu einem ganzzahligen Vielfachen einer Wellenlänge, die einer Spitzenfrequenz des von der Ablufteinheit erzeugten Rauschens entspricht, eine halbe Wellenlänge davon hinzuaddiert wurde, so dass der Schacht einen Interferenzdämpfer bildet.

4. Eisenbahnwaggon nach einem der vorhergehenden Ansprüche, wobei,
um zu verhindern, dass in der Klimaanlage erzeugtes Rauschen direkt von der ersten Öffnung (41) zu den zweiten Öffnungen (47a) übertragen wird, ein den Schacht erzeugendes Paneelelement oder ein den Schacht erzeugendes Paneelelement, das auf ein Paneelelement geschichtet wird, das auf der Kabinenseite angeordnete Dachelement erzeugt, im Wesentlichen direkt unterhalb der ersten Öffnung angeordnet ist.
5. Eisenbahnwaggon nach einem der vorhergehenden Ansprüche, wobei
die zwei zweiten Öffnungen (47a) nicht mit der ersten Öffnung (41a) in einer Höhenrichtung (530) des Eisenbahnwaggons fluchten und in einer Längsrichtung (520) oder einer Breitenrichtung (510) des Eisenbahnwaggons versetzt sind.
6. Eisenbahnwaggon nach einem der Ansprüche 1 bis 5, wobei

eine jeweilige poröse Platte (48) an einer der Kabine zugewandten Seite jeder zweiten Öffnung (47a) angeordnet ist; und

ein lokales Öffnungsverhältnis eines Bereichs jeder porösen Platte (48) nahe der ersten Öffnung (41) 5
niedrig eingestellt ist und ein lokales Öffnungsverhältnis eines Bereichs der porösen Platte (48) fern der ersten Öffnung (41) hoch eingestellt ist.

7. Eisenbahnwaggon nach einem der Ansprüche 1 bis 6, wobei
der Schacht (43) eine geräuschabsorbierende Funktion aufweist, die an dessen Strömungspfadseite vorgesehen ist; und
die geräuschabsorbierende Funktion durch Übernehmen mindestens einer der nachfolgenden Anordnungen vorgesehen ist: Bilden des den Schacht erzeugenden Paneelelements unter Verwendung eines porösen geräuschabsorbierenden Paneelelements; Anbringen eines geräuschabsorbierenden Paneelelements an das den Schacht erzeugende Paneelelement; und Anordnen eines geräuschabsorbierenden Gleichrichtelements auf dem den Schacht erzeugenden Paneelelement zum Glätten der Luftströmung, die den Strömungspfad passiert. 10
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8. Eisenbahnwaggon nach einem der Ansprüche 1 bis 7, wobei
der einen Interferenzdämpfer erzeugende Schacht (43) so angeordnet ist, dass ein Schacht mittig in der Breitenrichtung des Eisenbahnwaggon oder zwei Schächte an beiden Seiten in der Breitenrichtung des Eisenbahnwaggon angeordnet sind. 30

Revendications

1. Véhicule ferroviaire (1) comportant :

une structure de plafond (40) comprenant un appareil de conditionnement d'air (100) disposé sur une partie supérieure de celle-ci et ayant une première ouverture (41) permettant à l'air de s'écouler dans l'appareil de conditionnement d'air; 40

un élément de plafond disposé sur un côté inférieur de la structure de plafond pour définir un plafond (47) d'une cabine et ayant deux secondes ouvertures (47a) permettant à l'air de circuler depuis la cabine, et 45

un conduit (43) reliant la première ouverture (41) et les secondes ouvertures (47a) afin de constituer un trajet d'écoulement faisant communiquer la première ouverture (41) et les secondes ouvertures (47a), 50
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caractérisé en ce que une différence entre une distance (L1) dans une direction horizontale depuis la

première ouverture (41) jusqu'à l'une des secondes ouvertures (47a) et une distance (L2) dans une direction horizontale depuis la première ouverture (41) jusqu'à l'autre seconde ouverture (47a) est définie sensiblement égale à une longueur ayant un multiple entier d'une longueur d'onde correspondant à une fréquence de crête du bruit généré par l'appareil de conditionnement d'air auquel est ajouté une demi longueur d'onde correspondante, de sorte que le conduit constitue un silencieux à interférence.

2. Véhicule ferroviaire selon la revendication 1, dans lequel l'appareil de conditionnement d'air est muni d'une unité d'évacuation pour évacuer l'air contenu dans la cabine vers l'extérieur.

3. Véhicule ferroviaire comportant :

une structure de plafond ayant une unité d'évacuation disposée sur une partie supérieure de celle-ci pour évacuer l'air contenu dans une cabine vers l'extérieur et ayant une première ouverture (41) permettant à l'air de circuler dans l'unité d'évacuation,

un élément de plafond disposé sur un côté inférieur de la structure de plafond pour définir un plafond (47) de la cabine et ayant deux secondes ouvertures (47a) permettant à l'air de circuler depuis la cabine, et

un conduit (43) reliant la première ouverture (41) et les secondes ouvertures (47a) pour constituer un trajet d'écoulement faisant communiquer la première ouverture (41) et les secondes ouvertures (47a), 35

caractérisé en ce que une différence entre une distance (L1) dans une direction horizontale depuis la première ouverture (41) jusqu'à l'une des secondes ouvertures (47a) et une distance (L2) dans une direction horizontale depuis la première ouverture (41) jusqu'à l'autre seconde ouverture (47a) est définie sensiblement égale à une longueur ayant un multiple entier d'une longueur d'onde correspondant à une fréquence de crête du bruit généré par l'appareil de conditionnement d'air auquel est ajouté une demi longueur d'onde correspondante, de sorte que le conduit constitue un silencieux à interférence.

4. Véhicule ferroviaire selon l'une quelconque de revendications précédentes, dans lequel afin d'empêcher du bruit généré dans l'appareil de conditionnement d'air d'être transmis directement depuis la première ouverture (41) aux secondes ouvertures (47a), un élément de panneau constituant le conduit ou un élément de panneau constituant le conduit superposé sur un élément de panneau constituant l'élément de plafond disposé sur le côté de cabine est disposé sensiblement juste en

dessous de la première ouverture.

5. Véhicule ferroviaire selon l'une quelconque des revendications précédentes, dans lequel
les deux secondes ouvertures (47a) ne sont pas alignées avec la première ouverture (41) dans une direction de hauteur (530) du véhicule ferroviaire, et sont décalées dans une direction longitudinale (520) ou une direction de largeur (510) du véhicule ferroviaire. 5
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6. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 5, dans lequel
une plaque poreuse respective (48) est disposée sur chaque seconde ouverture (47a) sur un côté faisant face à la cabine, et 15
un rapport d'ouverture locale d'une zone de chaque plaque poreuse (48) proche de la première ouverture (41) est établi à faible et un rapport d'ouverture locale d'une zone de la plaque poreuse (48) éloignée de la première ouverture (41) est établi à élevé. 20

7. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 6, dans lequel
le conduit (43) dispose d'une fonction d'absorption des sons disposée sur le côté de trajet d'écoulement de celui-ci, et 25
la fonction d'absorption des sons est réalisée en adoptant au moins l'un des agencements suivants :
la formation de l'élément de panneau constituant le conduit en utilisant un élément de panneau d'absorption des sons poreux, la fixation d'un élément de panneau d'absorption des sons à l'élément de panneau constituant le conduit, et l'agencement d'un élément de correction d'absorption des sons sur l'élément de panneau constituant le conduit pour égaliser l'écoulement d'air circulant à travers le trajet d'écoulement. 30
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8. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 7, dans lequel 40
le conduit (43) constituant un silencieux à interférence est conçu de sorte qu'un conduit est disposé au centre dans la direction de largeur du véhicule ferroviaire ou les deux conduits sont disposés sur chaque côté dans la direction de largeur du véhicule ferroviaire. 45

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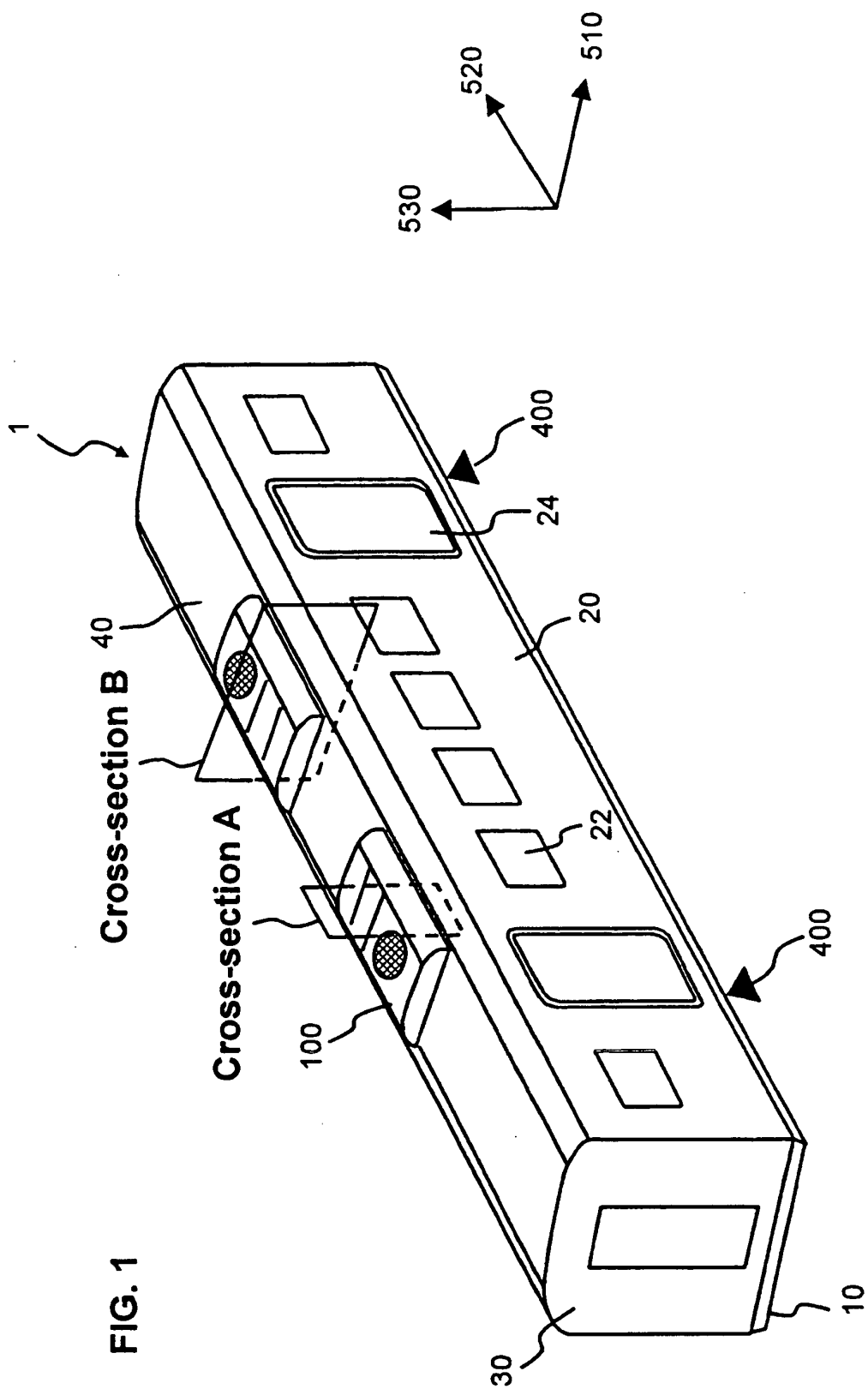


FIG. 2

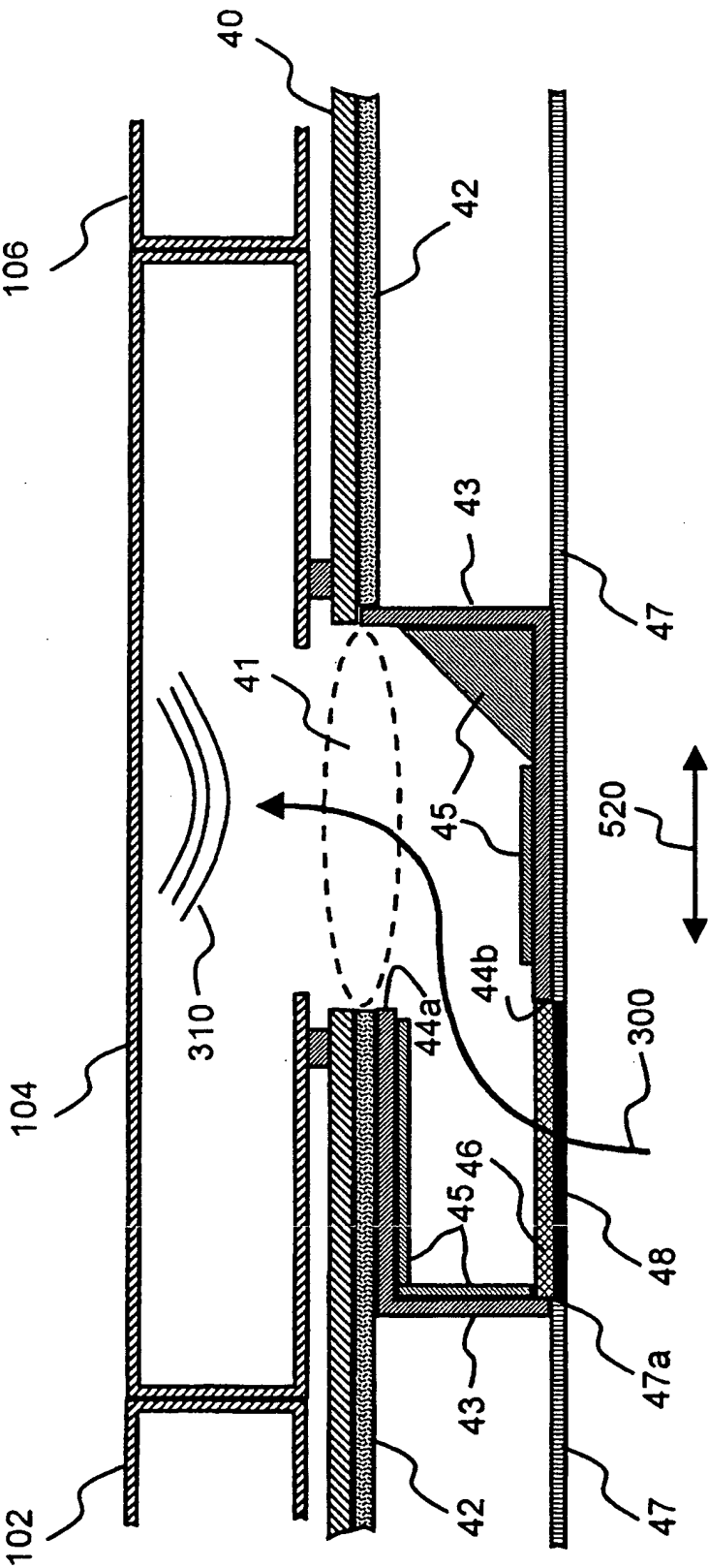


FIG. 3

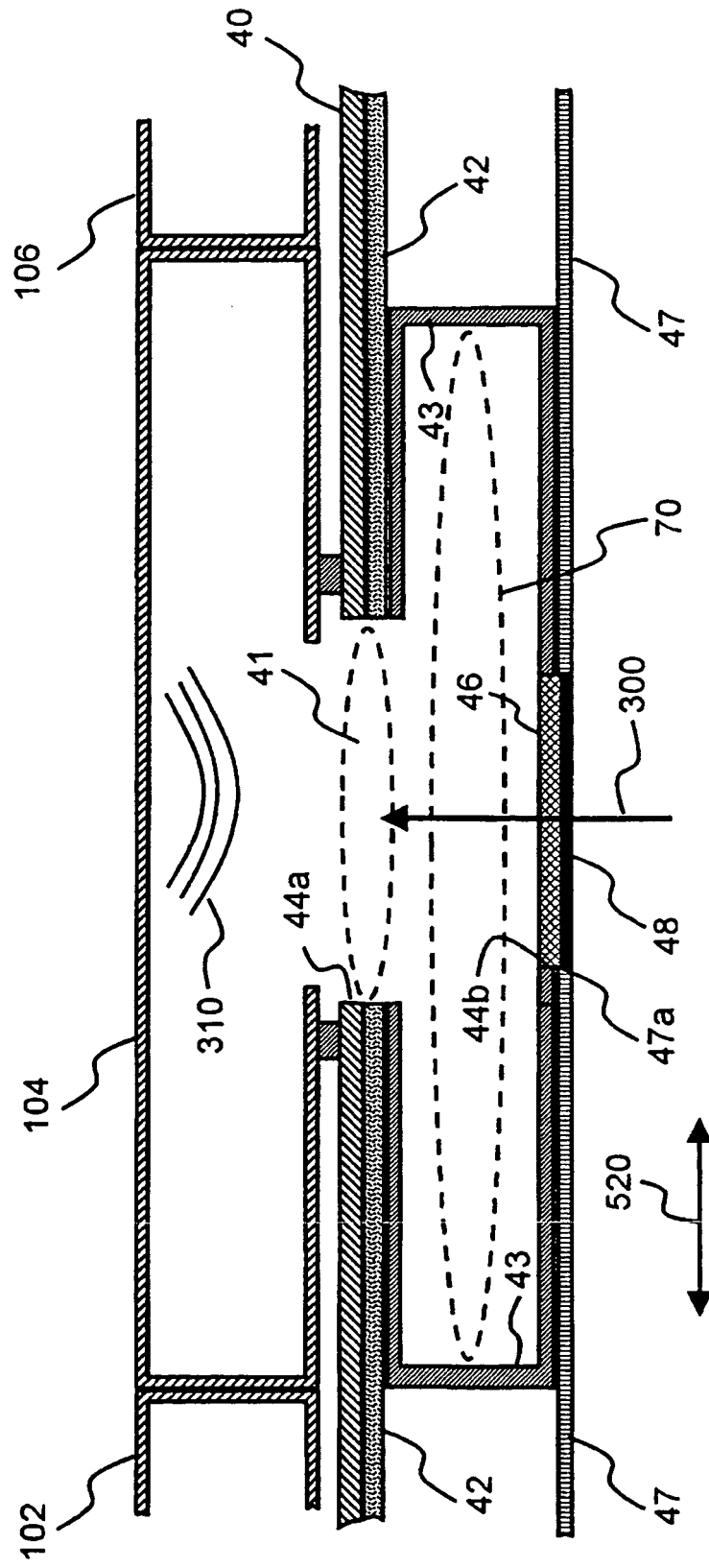


FIG. 4

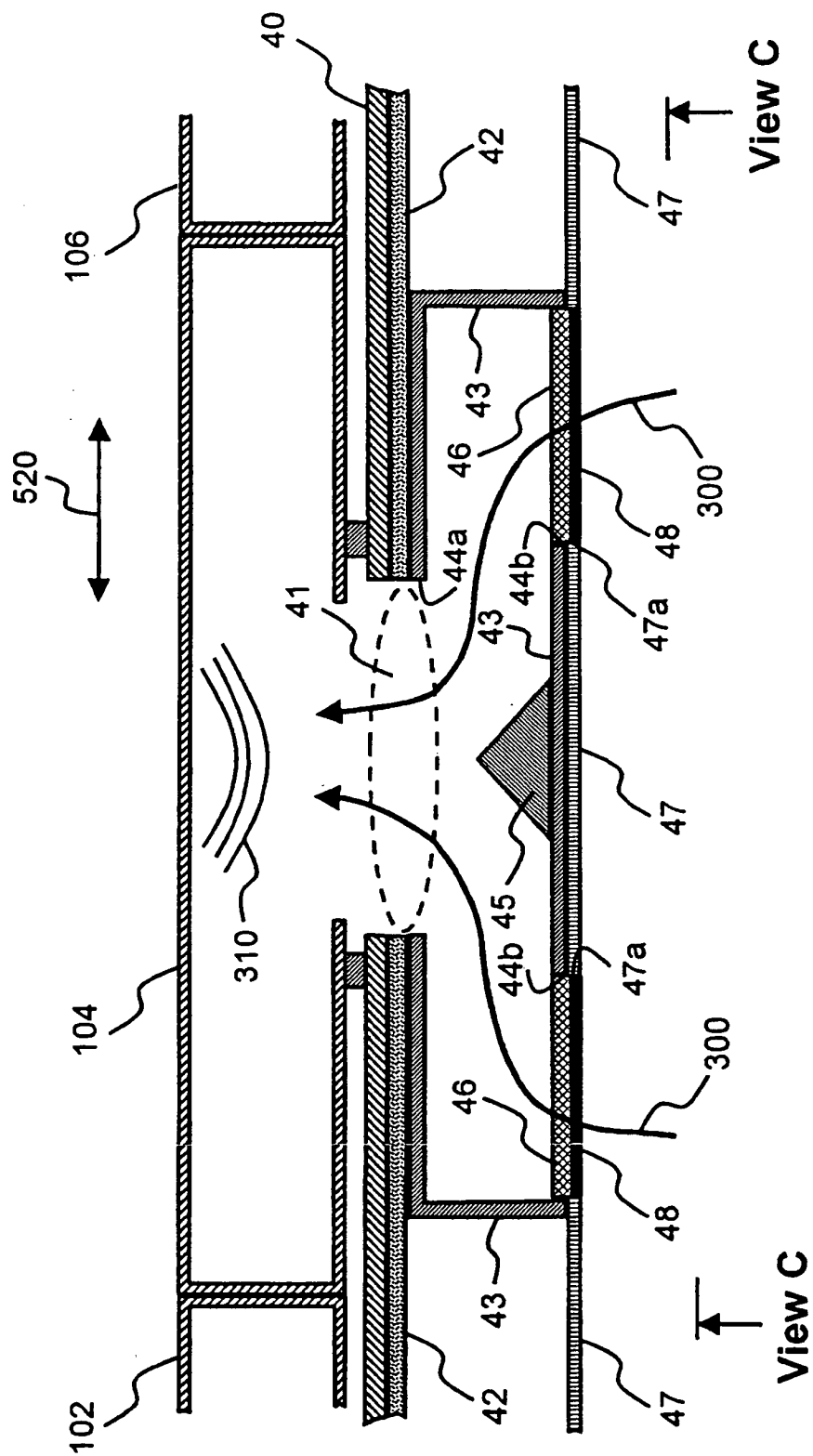


FIG. 5

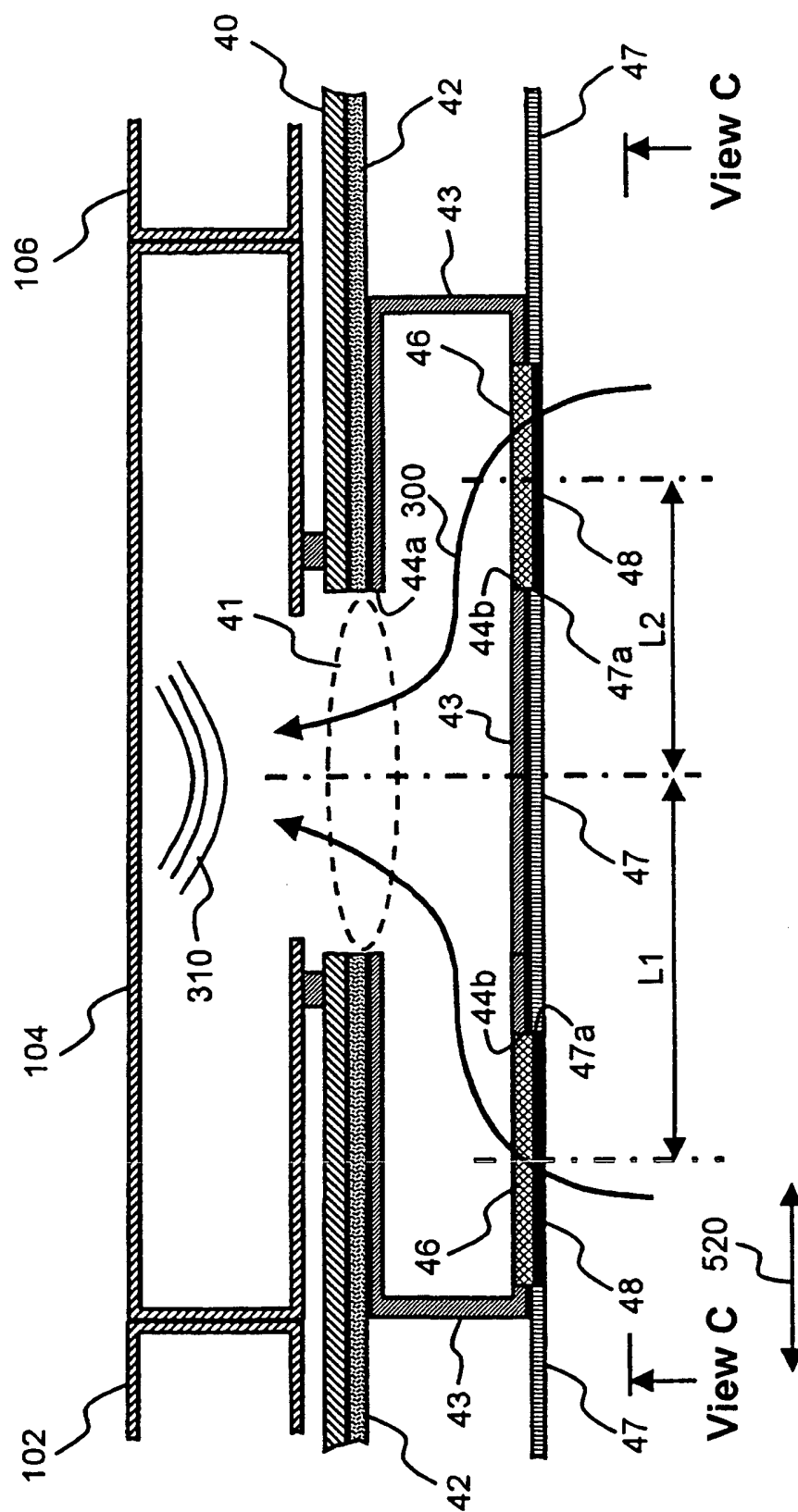
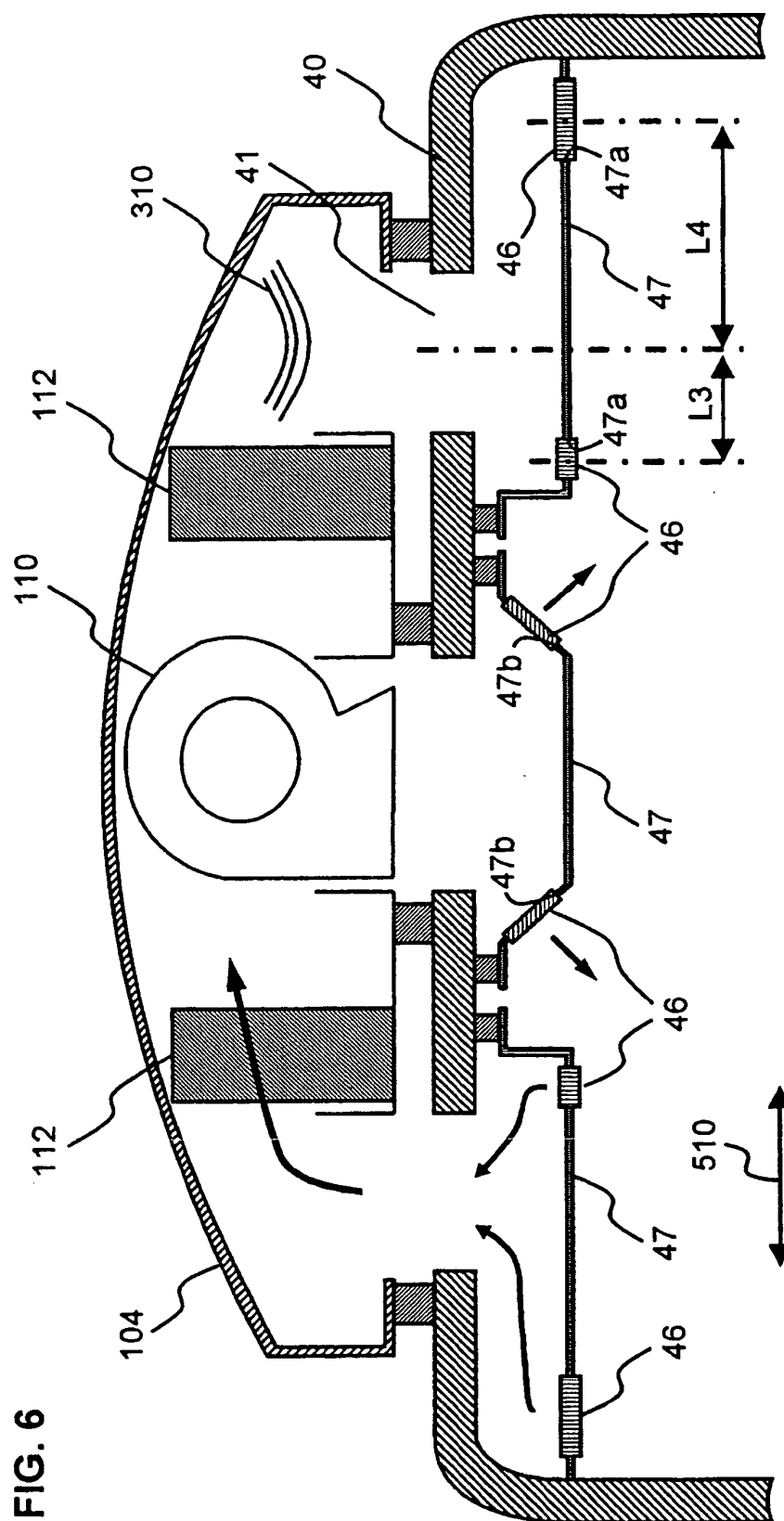


FIG. 6



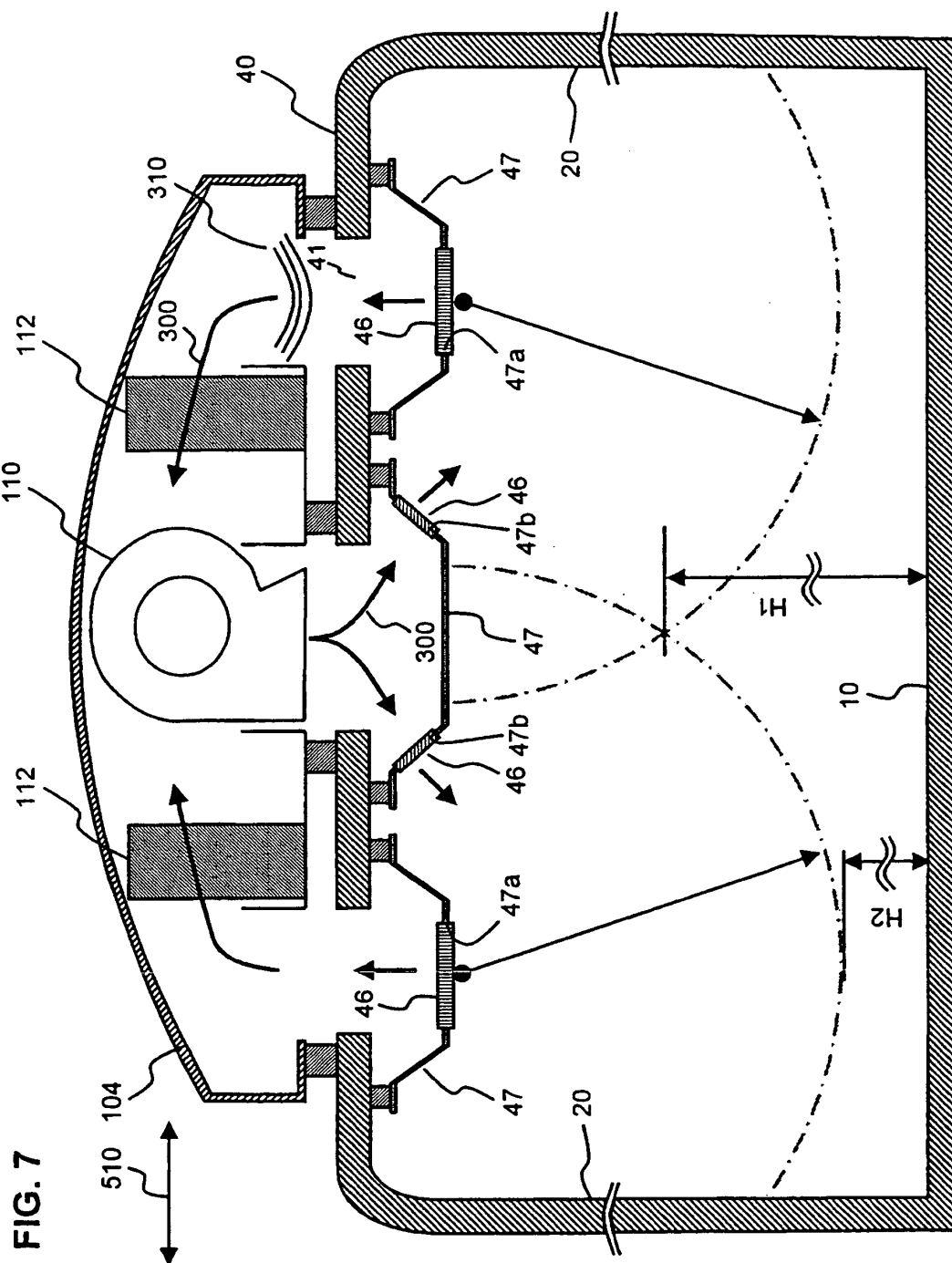


FIG. 8

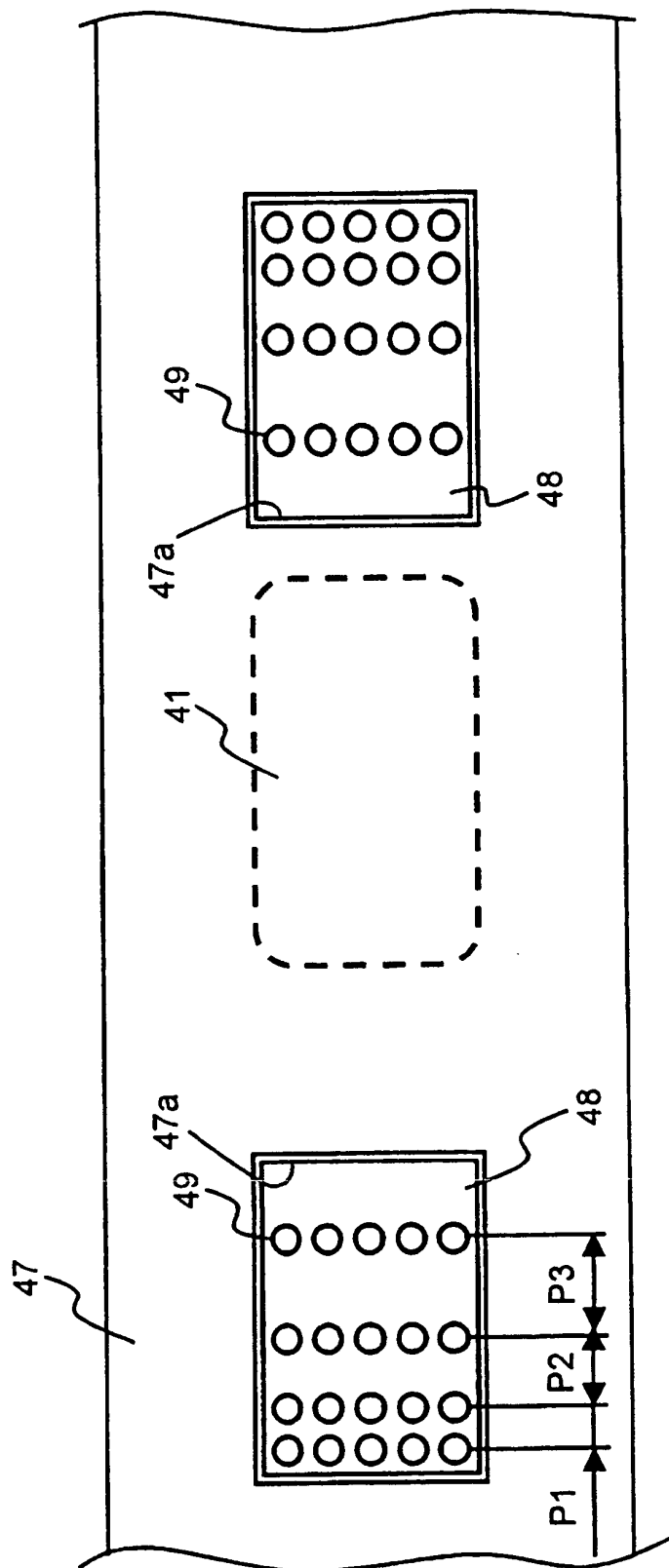


FIG. 9

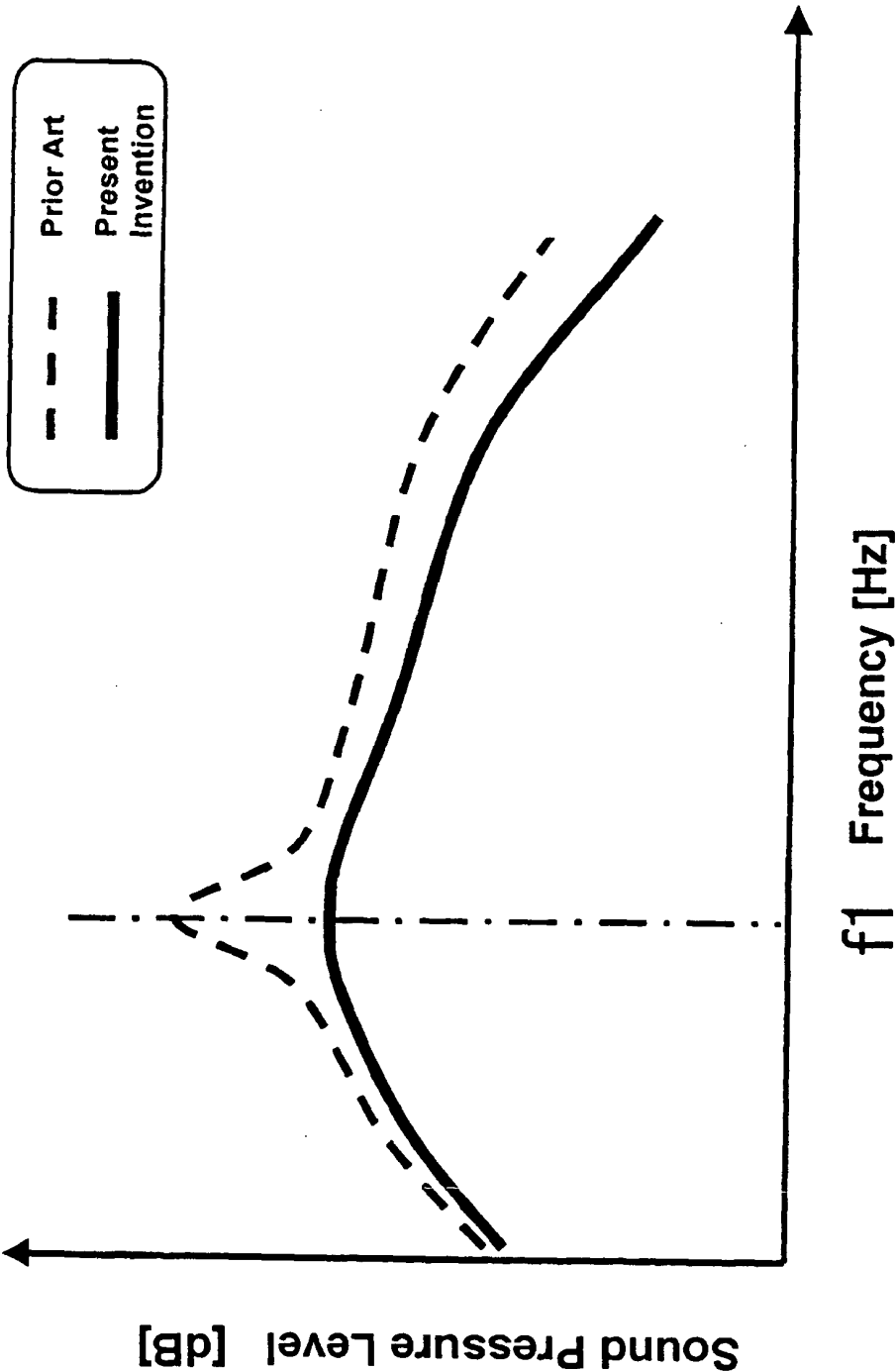
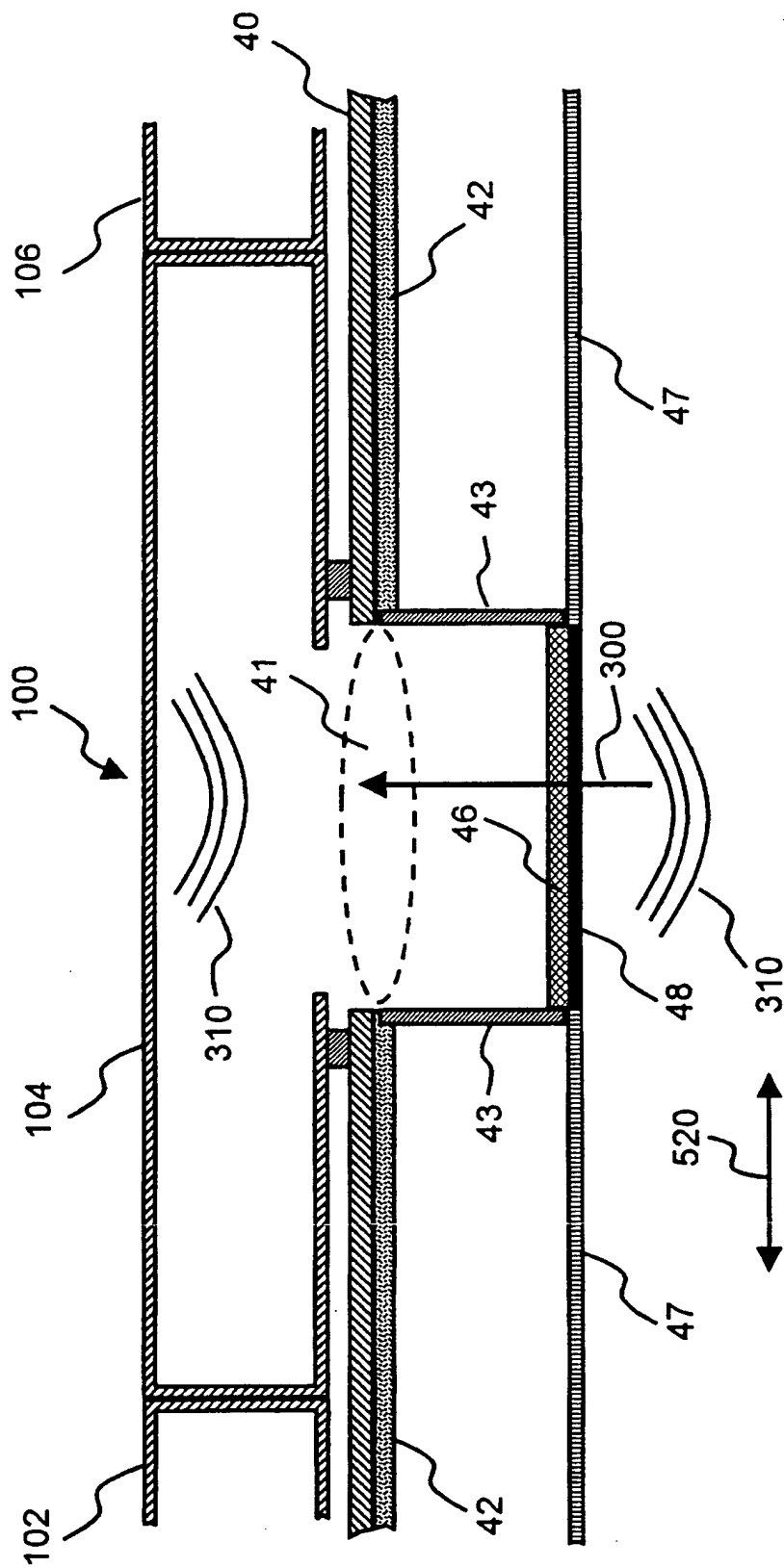


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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