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(54) Cooling arrangement for a vehicle

(57) Rail vehicle comprising a vehicle body (1.7) with a first air inlet (4.1) and a cooling arrangement (3) with a first heat exchanger device (5.1) and a ventilation device (6); said ventilation device (6) and said first air inlet (4.1) being associated to said first heat exchanger device (5.1); said ventilation device (6) being adapted to draw in cooling air from the surroundings of said vehicle body

(1.6) via said first air inlet (4.1) and to generate a first cooling air flow (8) at a heat exchanger surface of said first heat exchanger device (5.1) to draw heat from a cooling medium provided to said first heat exchanger device (5.1), wherein said ventilation device (6) and/or said first air inlet (4.1) is arranged obliquely and/or offset with respect to said first heat exchanger device (5.1).

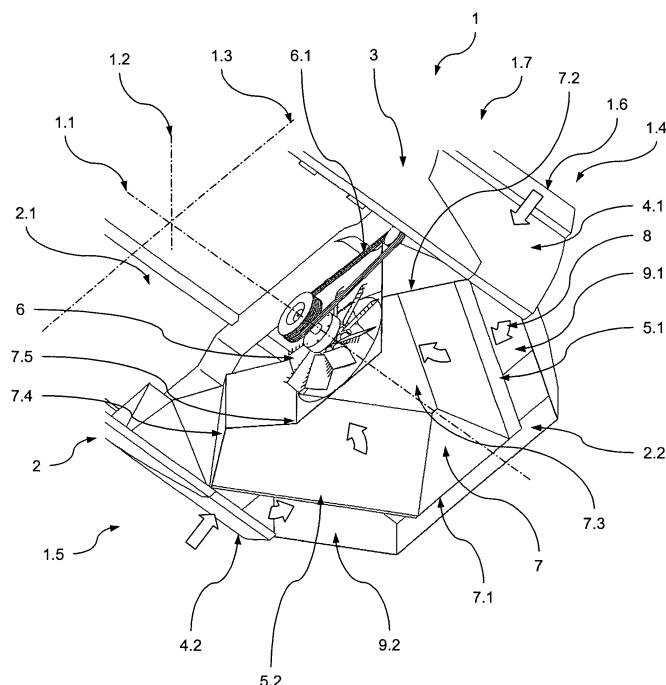


Fig. 1

DescriptionBACKGROUND OF THE INVENTION

[0001] The invention relates to a rail vehicle comprising a vehicle body with a first air inlet and a cooling arrangement with a first heat exchanger device and a ventilation device, the ventilation device and the first air inlet being associated to the first heat exchanger device, the ventilation device being adapted to draw in cooling air from the surroundings of the vehicle body via the first air inlet and to generate a first cooling air flow at a heat exchanger surface of the first heat exchanger device to draw heat from a cooling medium provided to the first heat exchanger device. The invention also relates to a corresponding train comprising such a rail vehicle.

[0002] In rail vehicles with equipment, such as e.g. the traction equipment, producing a considerable amount of lost heat cooling arrangements are provided to keep the temperature level within the lost heat generating equipment within predefined tolerable limits. In particular with rail vehicles where the traction equipment is mounted in underfloor sections of the vehicle, there is very limited space available for placing the components of the cooling arrangement.

[0003] To deal with this problem, the cooling arrangements used in these vehicles often comprise heat exchanger devices such as radiators mounted immediately behind vehicle cover panels. A fan or the like mounted immediately behind the respective radiator draws in cooling air via slots or the like forming cooling air inlets in the cover panels, thus generating cooling air flow over the heat exchanger surfaces of the radiator.

[0004] While being of rather compact design, these conventional cooling arrangement designs have the disadvantage that they have rather unfavorable sound emission properties. First of all, they generate themselves considerable noise. Furthermore, noise from the compartment where the traction equipment or any other heat generating equipment is housed is easily transmitted through these cooling arrangements leading to considerable overall noise emission level at the surroundings of the vehicle.

OBJECTS OF THE INVENTION

[0005] It is thus an object of the present invention to provide a rail vehicle that, at least to some extent, overcomes the above disadvantages. It is a further object of the present invention to provide a generic rail vehicle that provides effective cooling at reduced noise emission, in particular within the limited space available.

SUMMARY OF THE INVENTION

[0006] The above objects are achieved with a rail vehicle having the features of claim 1.

[0007] The present invention is based on the technical

teaching that effective cooling at reduced noise emission may be achieved if the ventilation device and/or the first air inlet is arranged obliquely and/or offset with respect to the first heat exchanger device. In either case, on the

5 one hand, a configuration may be achieved where there is no straight line of propagation of at least a considerable part the sound wave fronts between, both, the ventilation device and the first heat exchanger device, and the first air inlet. Thus, sound propagation from the vehicle interior to the surroundings of the vehicle may be effectively reduced since straight unhindered propagation towards the first air inlet and, thus, towards the vehicle surroundings is not possible anymore for at least a considerable part of the sound waves.

10 **[0008]** Furthermore, in particular due to the offset between the ventilation device and the first heat exchanger, the amount of noise generated by the cooling arrangement itself may be reduced. This is due to the fact that, with an offset between the ventilation device and the first

15 heat exchanger device effects of vibration excitation of the first heat exchanger device by the ventilation device, e.g. due to pressure pulsations or the like, are reduced considerably. If, for example, the ventilation device is a fan, in the known previous solutions, the rotor blades of

20 the fan rotated in close proximity to the ribs of the radiator. Every time, a rotor blade passed a rib of the radiator, the static pressure alteration in the gap between the rib and the rotor blade propagated itself as an audible periodic noise , resulted in a vibration excitation of the respective rib and, furthermore, reduced the efficiency of the fan.

25 **[0009]** A further beneficial effect of the above arrangement, in particular of the offset between the ventilation device and the first heat exchanger, is that due to the reduction of pressure pulsations, the flow at the heat exchanger surface of the heat exchanger device is rendered more uniform leading to higher heat exchange rates.

30 **[0010]** It should be noted that, in the sense of the invention, either of the components described, such as the ventilation device, the heat exchanger devices and the air inlets, may have a plane of main extension wherein it mainly extends (although the respective component does not necessarily have to be a planar body, such as a cuboid body, but may be totally or partially curved as

35 well). The term "arranged obliquely" is to be understood as an arrangement with a mutual inclination of the respective planes of main extension of the respective components. Furthermore, the term "offset" is to be understood as either an offset perpendicular to the planes of main extension or an offset parallel to the plane of main extension or both.

40 **[0011]** It will be appreciated that the first heat exchanger device and the ventilation device may be arranged in any suitable order along the cooling air stream subsequent to the first air inlet. Thus, in the direction of the cooling air stream it is possible that the ventilation device is arranged ahead of the first heat exchanger device, i.e. drawing the cooling air from the surroundings and press-

ing it through or past the first heat exchanger device. With preferred variants of the rail vehicle according to the invention, in the direction of the cooling air stream, the first heat exchanger device is arranged ahead of the ventilation device, such that the ventilation device draws the cooling air from the surroundings and through or past the first heat exchanger device. This has the advantage that the first heat exchanger device may act as a sound barrier for the noise originating from the vehicle interior, in particular noise originating from the ventilation device.

[0012] With preferred variants of the rail vehicle according to the invention, the first heat exchanger device defines a first surface on its air inlet side, the first surface being penetrated by the cooling air flow. The air inlet is arranged obliquely and/or offset with respect to the first heat exchanger device such that at most a first part of the surface normals of the first surface lie on a straight line from the first surface to the first air inlet. Thus, in other words, at most for only a first part of wave front of the sound waves emitted by the first heat exchanger device or penetrating the first heat exchanger device, there is a straight propagation path towards the first air inlet. Thus, sound emission to the surroundings via the first air inlet is reduced. It will be appreciated in this context that the first surface, in most cases, is an envelope surface defined by the heat exchanging elements (ribs, tubes etc.) of the first heat exchanger device.

[0013] The reduction of the straight line propagation fraction of the sound waves may be chosen as a function of the necessary sound emission reduction. Preferably, less than 50% of the surface normals of the first surface, preferably less than 20% of the surface normals of the first surface, more preferably substantially none of the surface normals of the first surface, lie on a straight line from the first surface to the first air inlet. Herewith, an increasing reduction in the sound emission may be achieved.

[0014] The part of the wave front of the sound waves emitted by the first heat exchanger device or penetrating the first heat exchanger device and having no straight line of propagation towards the first air inlet may be directed towards any component of the vehicle, e.g. an air duct wall etc. Preferably at least a part thereof is directed towards a first sound absorbing means in order to further reduce the sound emission. Preferably, the sound absorbing means is located close to the first heat exchanger device to provide its effects at the earliest possible moment. Thus, preferably, the surface normals of at least a second part of the first surface point towards a first sound absorbing means, in particular a first sound absorbing surface, the first sound absorbing means being located adjacent to the first heat exchanger device.

[0015] The fraction of the wave front directed towards the sound absorbing means may be chosen as a function of the necessary sound emission reduction. Preferably, more than 50% of the surface normals of the first surface, preferably more than 80% of the surface normals of the first surface, more preferably substantially all of the sur-

face normals of the first surface, point towards the first sound absorbing means. Herewith, an increasing reduction in the sound emission may be achieved.

[0016] In terms of cooling air flow, the connection of the ventilation device and the first heat exchanger device may be realized in any suitable way to guarantee the generation of a suitable cooling air flow. Preferably, a ventilation chamber is provided, the ventilation chamber having a first cooling air passage and a second cooling air passage. The first cooling air passage is formed by the first heat exchanger device and the second cooling air passage is formed by the ventilation device. The provision of such a ventilation chamber has the advantage that, on the one hand, it serves as an equalization means equalizing the flow conditions in the cooling air flow which, among others, reduces noise generating pressure oscillations in the cooling air flow. Furthermore, the ventilation chamber may serve as a noise trap, e.g. for noise originating from or intruding via the ventilation device.

[0017] The ventilation device may supply air to the ventilation chamber - i.e. generate an overpressure within the ventilation chamber - such that the cooling air flow at the heat exchanger surface of the first heat exchanger device is generated as the cooling air leaves the ventilation chamber via the first heat exchanger device. Preferably, that the ventilation device is adapted to draw air from the ventilation chamber - i.e. generate a negative pressure within the ventilation chamber - such that the cooling air flow at the heat exchanger surface of the first heat exchanger device is generated. Thus, the beneficial arrangement of the ventilation device and the first heat exchanger device as mentioned above may be achieved.

[0018] It will be appreciated that the ventilation chamber, apart from the cooling air passages taken by the ventilation device and one or several heat exchanger devices, preferably is a closed chamber. Preferably, it is sealed to be substantially airtight in order to minimize the losses in generating the cooling air flow and to provide a good sound trap as it has been mentioned above.

[0019] Preferably, the ventilation chamber is defined by at least one ventilation chamber wall, the at least one ventilation chamber wall comprising a second sound absorbing means, in particular a second sound absorbing surface. Thus, effect of the ventilation chamber as a sound trap is enhanced and the sound emission via the first air inlet may be considerably reduced.

[0020] The second sound absorbing means may be located at any suitable location within the ventilation chamber. Preferably, the second sound absorbing means is facing the ventilation device. Thus, at least a part of the noise originating from or intruding via the ventilation device is absorbed at a very early stage. Preferably all walls of the ventilation chamber, apart from the cooling air passages, are provided with sound absorbing means to enhance the described effect.

[0021] It will be appreciated that the sound absorbing means as disclosed herein may be any suitable means providing sound absorption. These may for example be

one or several sound absorbing elements or layers forming a surface of the respective component provided therewith. It may also be integrated within the wall of the respective component provided therewith.

[0022] Preferably, the ventilation chamber is defined by a plurality of ventilation chamber walls, the ventilation chamber walls being arranged such that a plurality of protrusions are formed within the ventilation chamber. This configuration has the beneficial effect that the sound waves, at these protrusions are reflected in different directions leading to a reduction in the noise emission from the ventilation chamber.

[0023] Depending on the design of the adjacent components of the vehicle, such as an engine, generator etc., the heat exchanger device may be arranged in any suitable and desired orientation with respect to the axes of the vehicle. Preferably, the rail vehicle has a longitudinal axis and a height axis and the heat exchanger device is inclined with respect to the longitudinal axis and/or the height axis. With such inclined arrangements, heat exchanger devices with considerable surface area and, thus, cooling capacity may be arranged in a relatively small space as it is often necessary in underfloor arrangements. With a given available space, the inclination with respect to the longitudinal axis and/or the height axis may be simply chosen as a function of the required cooling capacity of the heat exchanger device, i.e. the required surface area of a given heat exchanger device type.

[0024] The heat exchanger device may be of any suitable type and shape. Preferably, the heat exchanger device is a substantially planar element since, apart from its simple less costly design, the above orientation and arrangement at least widely avoiding straight line sound propagation towards the air inlet may be achieved in a very simple way. Preferably, the heat exchanger device is a radiator.

[0025] With preferred embodiments of the invention, at least one further air inlet is provided to reduce, among others, the local concentration of residual noise emission to the surroundings. Thus, preferably, the vehicle body comprises a second air inlet and the cooling arrangement comprises a second heat exchanger device. The second air inlet is associated to the second heat exchanger device and the ventilation device is adapted to draw in cooling air from the surroundings of the vehicle body via the second air inlet and to generate a second cooling air flow at a heat exchanger surface of the second heat exchanger device to draw heat from a cooling medium provided to the second heat exchanger device.

[0026] Preferably, the rail vehicle has a longitudinal axis and the first heat exchanger device and the second heat exchanger device are arranged on opposite sides of the longitudinal axis. Thus good noise emission reduction may be achieved. Preferably, the first heat exchanger device and the second heat exchanger device are arranged substantially symmetrical with respect to the longitudinal axis leading to a very simple and effective design.

[0027] As mentioned above, the invention may be implemented in the context of any arrangement of the cooling arrangement within the vehicle. Due to the very compact but strongly noise reducing configurations that may be realized, particular advantages are however obtained in the context of underfloor arrangements with their restricted available space. Thus, preferably the cooling arrangement is located in an underfloor section of the vehicle body.

[0028] The cooling arrangement may be associated to any hot heat producing component of the vehicle. Preferably, a engine is provided forming part of a traction equipment of the rail vehicle and the cooling arrangement is associated to the engine. This has the advantage that the ventilation device, in a very simple and economic way, may be directly driven by the engine.

[0029] The drive of the ventilation device may be of any suitable type, e.g. an electric drive, a hydraulic drive etc. Preferably, the ventilation device is mechanically coupled to the engine via an adjustable clutch device, in particular a viscous clutch device. Thus, additional noise emission due to the drive for the ventilation device may be reduced to a minimum.

[0030] It will be appreciated that the ventilation device may be any suitable device generating the cooling air flow. In very simple embodiments, the ventilation device comprises one or several fans operating in parallel and/or in series to generate the cooling air flow.

[0031] The invention further relates to a train, in particular a passenger train, comprising a rail vehicle according the invention.

[0032] Further embodiments of the present invention will become apparent from the dependent claims and the following description of a preferred embodiment of the invention which refers to the appended figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

40 Figure 1 is a schematic perspective bottom view of a part of a preferred embodiment of a rail vehicle according to the invention;

45 Figure 2 is a schematic sectional view of a part of the rail vehicle of Figure 1;

Figure 3 is a schematic sectional view of a part of the rail vehicle along line III-III of Figure 2.

50

55 **[0034]** In the following a preferred embodiment of a rail vehicle 1 according to the invention will be described with reference to Figure 1 to 3. The rail vehicle 1 is part of a passenger train according to the invention.

[0035] Figure 1 shows a schematic perspective bottom view of the vehicle 1 having a longitudinal axis 1.1, a

height axis 1.2 and a transverse axis 1.3. More specifically, Figure 1 shows a schematic perspective bottom view of a part of an underfloor compartment 2 of the vehicle 1. The bottom wall of the underfloor compartment 2 covering the underfloor compartment 2 towards the track is omitted in Figure 1.

[0036] Figure 2 is a schematic sectional view of the cooling arrangement 3 of the rail vehicle of Figure 1 along line II-II of Figure 3. The sectional plane of Figure 2 is perpendicular to the height axis 1.2 and located immediately below the top plate covering the underfloor compartment 2 and separating the underfloor compartment 2 from a transport compartment, e.g. a passenger compartment, of the vehicle 1. Figure 3 is a schematic sectional view of the cooling arrangement 3 along line III-III of Figure 2.

[0037] The underfloor compartment 2 has a first section 2.1 receiving a engine (not shown) and a second section 2.2 located ahead of the first section 2.1 and receiving a cooling arrangement 3. The cooling arrangement 3 serves to draw heat from a cooling liquid used to keep the temperature of the engine and its components within predetermined levels.

[0038] The cooling arrangement 3 comprises a first air inlet 4.1, a first heat exchanger device in the form of a first radiator 5.1 and a ventilation device in the form of a fan 6. The cooling arrangement 3 further comprises a second air inlet 4.2, a second heat exchanger device in the form of a second radiator 5.1.

[0039] The fan 6 is directly driven by the engine (not shown) via a drive mechanism 6.1 comprising a controllable viscous clutch element. This has the advantage that, while being able to control the fan speed, additional noise emission due to the drive for the fan 6 may be reduced to a minimum.

[0040] The first air inlet 4.1 and the second air inlet 4.2 are arranged on opposite longitudinal sides 1.4 and 1.5 of the vehicle 1. The first air inlet 4.1 and the second air inlet 4.2 are formed in the outer shell 1.6 of the vehicle body 1.7 and each have a plurality openings (not shown), such as slots, holes or the like, allowing the passage of air into the underfloor compartment 2. The first air inlet 4.1 and the second air inlet 4.2 may also have means, such as air guide elements or the like, providing at least rough cleaning of the cooling air from dirt, water or other liquids.

[0041] In the embodiment shown, the first air inlet 4.1 and the second air inlet 4.2 as well as the first radiator 5.1 and the second radiator 5.2 are arranged to be mirror symmetric with respect to the longitudinal plane of the vehicle 1 defined by the longitudinal axis 1.1 and the height axis 1.2. Thus, in the following mainly the first air inlet 4.1 and the first radiator 5.1 will be described in an exemplary manner. However, it will be appreciated that, with other embodiments of the invention, either first air inlet 4.1 and the second air inlet 4.2 or the first radiator 5.1 and the second radiator 5.2 may be arranged and designed differently.

[0042] The cooling arrangement 3 further comprises a ventilation chamber 7 with a front wall 7.1, a rear wall 7.2, a top wall 7.3 and a bottom wall (not shown) formed by the bottom wall of the underfloor compartment 2.

[0043] The first radiator 5.1 and the second radiator 5.2 form further wall elements of the ventilation chamber 7. The first radiator 5.1 is a element of generally cubic outer shape having a plane of main extension - represented by line 5.3 in Figures 2 and 3. The first radiator 5.1 has a plurality of heat exchanging elements (not shown), such as cooling liquid ducts with ribs or the like, forming the heat exchanger surface of the first radiator 5.1. The first radiator 5.1, among others, on its air inlet side (i.e. its side towards the first air inlet 4.1) defines a first surface 5.4 which is an envelope surface of the heat exchanging elements. These heat exchanging elements are arranged within the cubic outer shape of the first radiator 5.1 such that, for cooling purposes, a flow cooling air 8.1 may be led through the first radiator 5.1 perpendicular to its plane of main extension. Thus, the first radiator 5.1 forms a first cooling air passage of the ventilation chamber 7.

[0044] The rear wall 7.2 of the ventilation chamber 7 has a circular opening adapted to the shape of the fan 6 such that the fan forms a second cooling air passage of the ventilation chamber 7. The fan 6 draws air from the ventilation chamber 7 and, thus, generates a negative pressure within the ventilation chamber 7. This negative pressure within the ventilation chamber 7 causes cooling air from the surroundings of the vehicle to be drawn via the air inlets 4.1, 4.2, the air ducts 9.1 and 9.2 and the radiators 5.1, 5.2 into the ventilation chamber 7. Thus, a first cooling air flow 8.1 at the heat exchanger surface of the first radiator 5.1 is generated to draw heat from the cooling liquid provided to the first radiator 5.1.

[0045] As mentioned, the fan draws the heated cooling air from the ventilation chamber 7 towards the first section 2.1 of the underfloor compartment 2. Here, depending on its temperature, it may be guided and used to cool further components arranged within the first section 2.1 of the underfloor compartment 2. However, it may also be vented back to the surroundings of the vehicle.

[0046] It will be appreciated that, with other embodiments of the invention, the fan 6 may also supply cooling air (drawn in by suitable ducts) towards the ventilation chamber 7. This cooling air is then vented to the surroundings of the vehicle via the radiators 5.1 and 5.2, the air ducts 9.1 and 9.2 and the air inlets 4.1, 4.2.

[0047] The ventilation chamber 7, apart from the cooling air passages formed by the radiators 5.1, 5.2 and the fan 6, is sealed to be substantially airtight in order to reduce the ventilation losses to a minimum. The same applies to the air ducts 9.1, 9.2 which are sealed apart from the cooling air passages formed by the air inlets 4.1, 4.2 and the radiators 5.1, 5.2.

[0048] As can be seen from Figure 1 and 2, the fan 6 is arranged offset with respect to the first radiator 5.1. Thus, the amount of the noise generated by the cooling

arrangement 3 itself is reduced. This is due to the fact that, with the offset between the fan 6 and the first radiator 5.1 effects of vibration excitation of the first radiator 5.1 by the fan 6, e.g. due to pressure pulsations or the like, are reduced considerably. Furthermore, the air volume in the ventilation chamber 7 damps the noise resulting from static pressure alterations generated by the fan.

[0049] Furthermore, the fan 6 is arranged obliquely with respect to the first radiator 5.1. As mentioned above, The term "arranged obliquely" is to be understood as an arrangement with a mutual inclination of the respective planes of main extension of the respective components. Here, the plane of main extension of the fan 6 - represented by line 6.2 in Figure 2 - is perpendicular to the longitudinal axis 1.1 of the vehicle 1 while the plane of main extension of the first radiator 5.1 - represented by line 5.3 in Figure 2 and 3 - is inclined with respect to the longitudinal axis 1.1 (see Figure 1 and 2) and the height axis 1.2 (see Figure 1 and 3) of the vehicle 1.

[0050] The oblique arrangement of the fan 6 and the first radiator 5.1. has the advantage that the sound wave front coming from the fan 6 hits the first radiator 5.1 only under an acute angle leading to a reduced immediate penetration of sound through the first radiator 5.1 as well as a reduced vibration excitation of the first radiator 5.1.

[0051] Depending on the inclination between the fan 6 and the first radiator 5.1, a considerable amount of the sound energy first hits the front wall 7.1 of the ventilation chamber. To reduce the fraction of this sound energy reflected back by the front wall 7.1, the front wall 7.1 is provided with sound absorbing means in the form of one or several sound absorbing elements mounted to its surface facing the fan 6. Such sound absorbing elements are well known in the art and, thus, will not be described here in further detail.

[0052] To further reduce the amount of sound energy that may penetrate the first radiator 5.1 towards the surroundings of the vehicle 1, all other solid walls, such as walls 7.2, 7.3, of the ventilation chamber 7 are provided with such sound absorbing means as well. Furthermore, the solid walls of the ventilation chamber 7 form several protrusions 7.4 and indentations 7.5. This configuration has the beneficial effect that the sound waves, at these protrusions 7.4 and indentations 7.5, are reflected in different directions leading to a reduction in the noise emission from the ventilation chamber 7. Thus, in summary, the ventilation chamber 7 acts a noise trap.

[0053] To further reduce the amount of sound energy that may escape towards the surroundings of the vehicle 1, the first radiator 5.1 is offset in the direction of the longitudinal axis 1.1 and in the direction of the transverse axis 1.3 as well as arranged obliquely with respect to the first air inlet 4.1. As mentioned above the oblique arrangement is such that an inclination exists between the plane of main extension 5.3 of the first radiator 5.1 and the plane of main extension of the first air inlet - indicated by line 4.3 in Figure 2 and 3.

[0054] The mutual arrangement the first radiator 5.1

and the first air inlet 4.1 is such that only a very small first part, here less than 20%, of the surface normals 5.5 of the first surface 5.4 of the first radiator 5.1 lies on a straight line from the first surface 5.4 to the first air inlet 4.1. Thus, only the part of the sound wave front coming from the first radiator 5.1 and related to this first part of surface normals 5.5 directly hits the first air inlet 4.1. Thus, a reduced immediate penetration of sound through the first air inlet 4.1 as well as a reduced vibration excitation of the first air inlet 4.1 is achieved.

[0055] The remaining second part, here more than 80%, of the surface normals 5.5 of the first surface 5.4 is directed towards the adjacent walls of the air duct 9.1. To reduce the amount of reflected sound energy that may penetrate the first air inlet 4.1 towards the surroundings of the vehicle 1, all the walls of the air duct 9.1 are provided with sound absorbing means as they have been described above. However, it will be appreciated that, with other embodiments of the invention, only a part of the walls of the air duct 9.1, in particular, only the part to which the surface normals 5.5 point, may be provided with sound absorbing means. Furthermore, such sound absorbing means may be omitted as well.

[0056] It will be appreciated that, depending on the necessary reduction of the noise emission towards the surroundings of the vehicle 1, the part of the surface normals 5.5 of the first surface 5.4 lying on a straight line from the first surface 5.4 to the first air inlet 4.1 may be further reduced by further offsetting the first radiator 5.1 and the first air inlet 4.1 and/or by modifying the inclination between the first radiator 5.1 and the first air inlet 4.1. The part of the surface normals 5.5 of the first surface 5.4 lying on a straight line from the first surface 5.4 to the first air inlet 4.1 may even be reduced to zero, if necessary.

[0057] It will be further appreciated that, depending on the necessary cooling capacity of the first radiator 5.1, a larger or smaller radiator may be implemented by simply modifying the inclination of the radiator with respect to the longitudinal axis 1.1 and/or the height axis 1.2 as it is indicated in Figure 3 by the dashed contour 10.

[0058] Furthermore, it will be appreciated that, the invention allows implementation of a cooling arrangement of suitable cooling capacity even at very restricted space requirements. In particular, with a given available space for the cooling arrangement, the cooling capacity may be easily adapted to the required amount by adapting the inclination and, thus, the size of the heat exchangers.

[0059] Furthermore, it will be appreciated that, with other embodiments of the invention, an inclination of the first radiator with respect to either the longitudinal axis 1.1 or the height axis 1.2 may be sufficient to achieve the above effects of sound reduction by reducing the part of the surface normals of the first surface of the first radiator lying on a straight line from the first surface to the first air inlet. Furthermore, even no inclination with respect to the longitudinal axis 1.1 and the height axis 1.2 but a sufficient offset along the longitudinal axis 1.1 (as it is indi-

cated by the dashed contour 11 in Figure 2) may be sufficient.

[0060] In the foregoing, the invention has been described with reference to an embodiment where a pair of heat exchanger devices has been used. However, it will be appreciated that, with other embodiments of the invention, another number of heat exchanger devices may be selected.

Claims

1. Rail vehicle comprising:

- a vehicle body (1.7) with a first air inlet (4.1) and
- a cooling arrangement (3) with a first heat exchanger device (5.1) and a ventilation device (6);
- said ventilation device (6) and said first air inlet (4.1) being associated to said first heat exchanger device (5.1);
- said ventilation device (6) being adapted to draw in cooling air from the surroundings of said vehicle body (1.6) via said first air inlet (4.1) and to generate a first cooling air flow (8) at a heat exchanger surface of said first heat exchanger device (5.1) to draw heat from a cooling medium provided to said first heat exchanger device (5.1),

characterized in that

- said ventilation device (6) and/or said first air inlet (4.1) is arranged obliquely and/or offset with respect to said first heat exchanger device (5.1).

2. Rail vehicle according to claim 1, **characterized in that**

- said first heat exchanger device (5.1) defines a first surface (5.4) on its air inlet side, said first surface (5.4) being penetrated by said cooling air flow (8);
- said air inlet (4.1) being arranged obliquely and/or offset with respect to said heat exchanger device (5.1) such that at most a first part of the surface normals (5.5) of said first surface (5.4) lie on a straight line from said first surface (5.4) to said first air inlet (4.1).

3. Rail vehicle according to claim 2, **characterized in that** less than 50% of said surface normals (5.5) of said first surface (5.4), preferably less than 20% of said surface normals (5.5) of said first surface (5.4), more preferably substantially none of said surface normals (5.5) of said first surface (5.4), lie on a straight line from said first surface (5.4) to said first air inlet (4.1).

4. Rail vehicle according to claim 2 or 3, **characterized in that**

- the surface normals (5.5) of at least a second part of said first surface (5.4) point towards a first sound absorbing means, in particular a first sound absorbing surface;
- said first sound absorbing means being located adjacent to said first heat exchanger device (5.1).

5. Rail vehicle according to claim 4, **characterized in that** more than 50% of said surface normals (5.5) of said first surface (5.4), preferably more than 80% of said surface normals (5.5) of said first surface (5.4), more preferably substantially all of said surface normals (5.5) of said first surface (5.4), point towards said first sound absorbing means.

20 6. Rail vehicle according to any one of the preceding claims, **characterized in that**

- a ventilation chamber (7) is provided,
- said ventilation chamber (7) having a first cooling air passage and a second cooling air passage;
- said first cooling air passage being formed by said first heat exchanger device (5.1) and said second cooling air passage being formed by said ventilation device (6).

30 7. Rail vehicle according to claim 6, **characterized in that** said ventilation device (6) is adapted to draw air from said ventilation chamber (7) such that said cooling air flow (8) at said heat exchanger surface of said first heat exchanger device (5.1) is generated.

35 8. Rail vehicle according to claim 6 or 7, **characterized in that**

- said ventilation chamber (7) is defined by at least one ventilation chamber wall (7.1, 7.2, 7.3);
- said at least one ventilation chamber wall (7.1, 7.2, 7.3) comprising a second sound absorbing means, in particular a second sound absorbing surface.

40 9. Rail vehicle according to claim 8, **characterized in that** said second sound absorbing means is facing said ventilation device (6).

45 10. Rail vehicle according to any one of claims 6 to 9, **characterized in that**

- said ventilation chamber (7) is defined by a plurality of ventilation chamber walls (7.1, 7.2, 7.3);
- said ventilation chamber walls (7.1, 7.2, 7.3)

being arranged such that a plurality of protrusions (7.4) and/or indentations (7.5) are formed within said ventilation chamber (7).

11. Rail vehicle according to any one of the preceding claims, **characterized in that**

- it has a longitudinal axis (1.1) and a height axis (1.2);
- said heat exchanger device (5.1) being inclined with respect to said longitudinal axis (1.1) and/or said height axis (1.2).

12. Rail vehicle according to any one of the preceding claims, **characterized in that** said heat exchanger device (5.1) is a substantially planar element.

13. Rail vehicle according to any one of the preceding claims, **characterized in that** said heat exchanger device is a radiator (5.1).

14. Rail vehicle according to any one of the preceding claims, **characterized in that**

- said vehicle body (1.6) comprises a second air inlet (4.2) and
- said cooling arrangement (3) comprises a second heat exchanger device (5.2);
- said second air inlet being (4.2) associated to said second heat exchanger device (5.2);
- said ventilation device (6) being adapted to draw in cooling air from the surroundings of said vehicle body (1.6) via said second air inlet (4.2) and to generate a second cooling air flow at a heat exchanger surface of said second heat exchanger device (5.2) to draw heat from a cooling medium provided to said second heat exchanger device (5.2).

15. Rail vehicle according to claim 14, **characterized in that**

- it has a longitudinal axis (1.1);
- said first heat exchanger device (5.1) and said second heat exchanger device (5.2) being arranged on opposite sides of said longitudinal axis (1.1), in particular being arranged substantially symmetrical with respect to said longitudinal axis (1.1).

16. Rail vehicle according to any one of the preceding claims, **characterized in that** said cooling arrangement (3) is located in an underfloor section (2) of said vehicle body (1.6).

17. Rail vehicle according to any one of the preceding claims, **characterized in that**

- an engine is provided forming part of a traction equipment of said rail vehicle;
- said cooling arrangement (3) being associated to said engine.

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18. Rail vehicle according to claim 17, **characterized in that** said ventilation device (6) is directly driven by said engine.

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19. Rail vehicle according to claim 17 or 18, **characterized in that** said ventilation device (6) is mechanically coupled to said engine via an adjustable clutch device, in particular a viscous clutch device.

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20. Train, in particular passenger train, comprising a rail vehicle (1) according to any one of the preceding claims.

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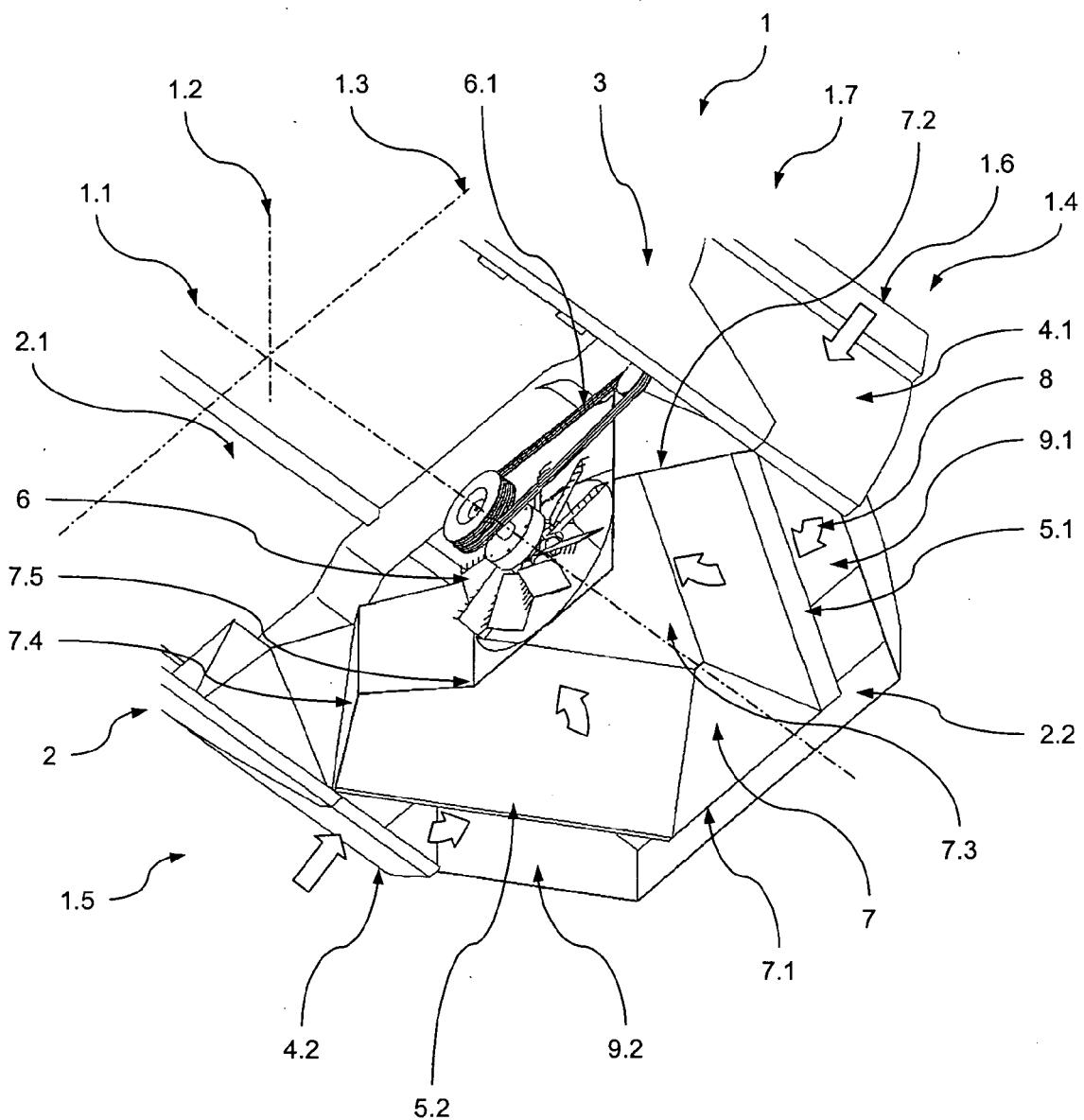


Fig. 1

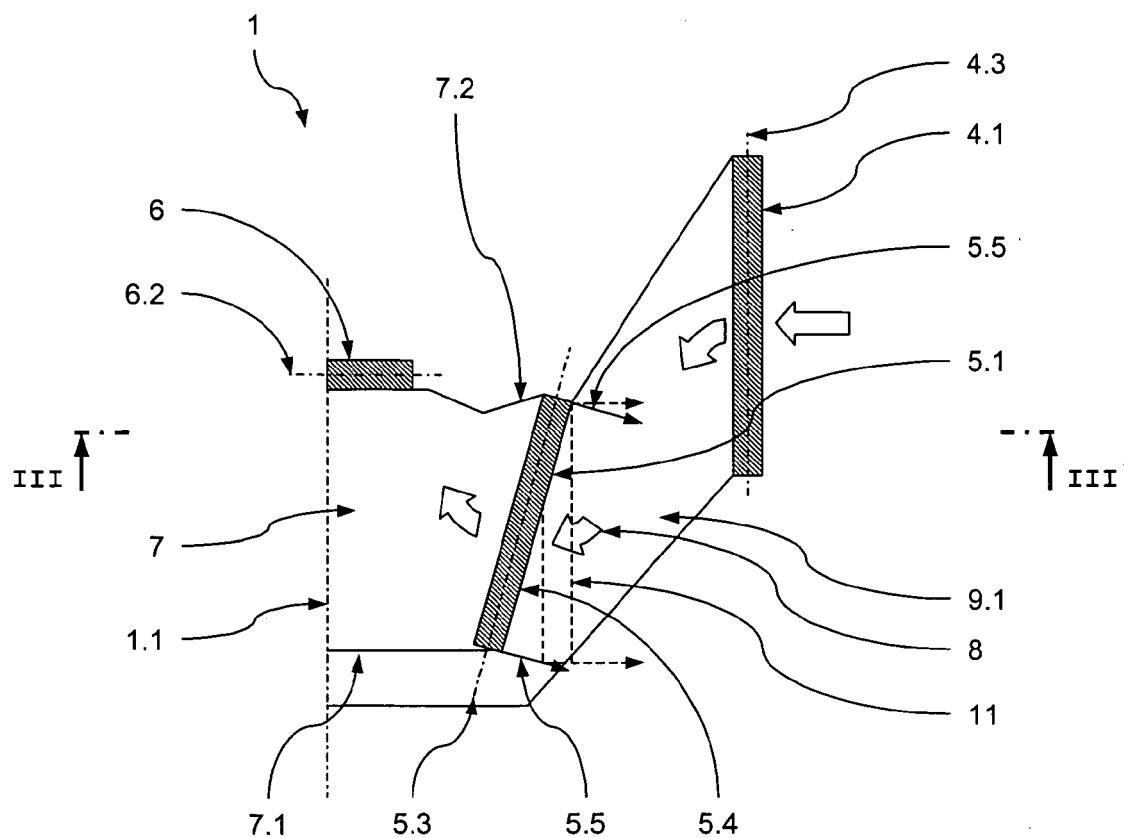


Fig. 2

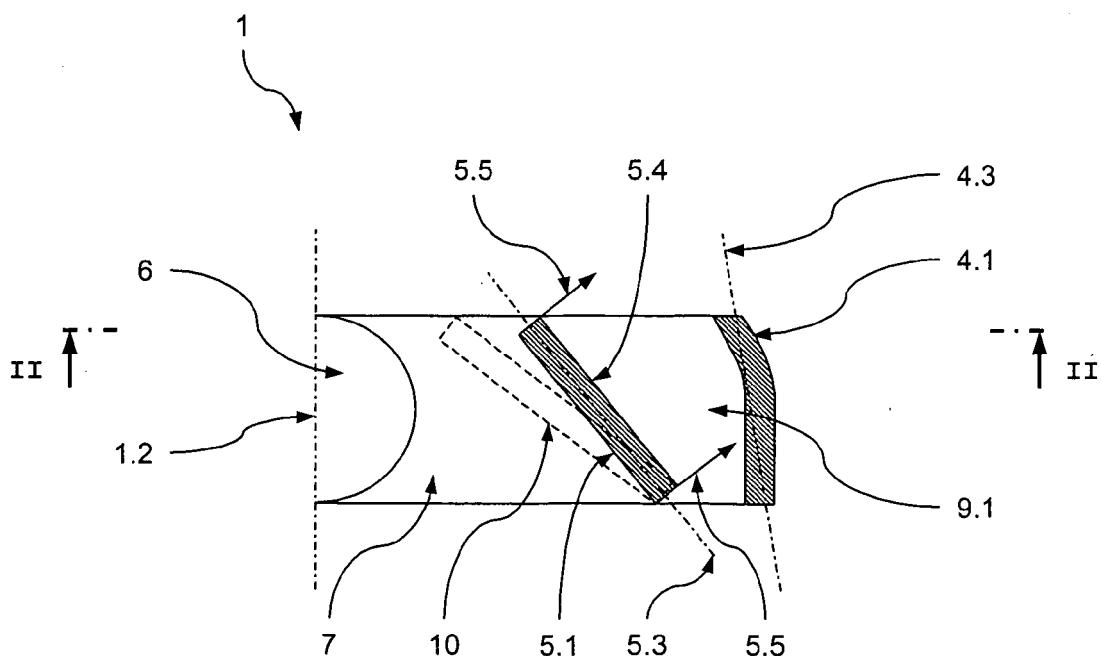


Fig. 3



| DOCUMENTS CONSIDERED TO BE RELEVANT | | | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|----------------------------------|---|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | |
| X | US 5 074 122 A (BABIN ET AL) 24 December 1991 (1991-12-24) * column 4, line 65 - column 5, line 23 * * column 6, line 1 - line 31; figure 3 * ----- | 1-3,7, 11-13, 16,20 | INV. B61D27/00 |
| X | US 4 905 478 A (MATSUDA ET AL) 6 March 1990 (1990-03-06) * column 2, line 29 - column 3, line 62; figures 1-4 * ----- | 1,2,7, 11-13, 15,20 | |
| A | DE 101 18 219 A1 (DAIMLERCHRYSLER RAIL SYSTEMS GMBH) 17 October 2002 (2002-10-17) * paragraph [0013] - paragraph [0015]; figures 1,2 * ----- | 4,5,8,16 | |
| A | EP 1 081 439 A (LIEBHERR-VERKEHRSTECHNIK GMBH; LIEBHERR-TRANSPORTATION SYSTEMS GMBH) 7 March 2001 (2001-03-07) * paragraph [0008]; claim 3; figures 1,2 * ----- | 4,5,8 | TECHNICAL FIELDS SEARCHED (IPC) |
| | | | B61D B61C B60H |
| The present search report has been drawn up for all claims | | | |
| 1 | Place of search | Date of completion of the search | Examiner |
| | The Hague | 4 July 2006 | Chlosta, P |
| CATEGORY OF CITED DOCUMENTS | | | |
| X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document | | | |
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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 06 00 1715

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-07-2006

| Patent document cited in search report | | Publication date | | Patent family member(s) | Publication date |
|--|----|------------------|--|---|--|
| US 5074122 | A | 24-12-1991 | AT AU CA DE DE DE EP ES FR JP KR | 115078 T 5485790 A 2016260 A1 69014711 D1 69014711 T2 397557 T1 0397557 A1 2018457 T3 2646822 A1 2310115 A 9508506 B1 | 15-12-1994 15-11-1990 10-11-1990 19-01-1995 06-07-1995 21-03-1991 14-11-1990 01-04-1995 16-11-1990 25-12-1990 31-07-1995 |
| US 4905478 | A | 06-03-1990 | KR US | 9607043 B1 4982583 A | 27-05-1996 08-01-1991 |
| DE 10118219 | A1 | 17-10-2002 | CN CZ WO EP | 1498176 A 20032761 A3 02090165 A1 1377488 A1 | 19-05-2004 18-02-2004 14-11-2002 07-01-2004 |
| EP 1081439 | A | 07-03-2001 | AT DE ES HU SK | 313765 T 29915543 U1 2255217 T3 9903785 A2 146399 A3 | 15-01-2006 18-01-2001 16-06-2006 28-06-2001 10-05-2001 |