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(54) **Cooling braking resistors of a track bound vehicle**

(57) The invention relates to an arrangement for cooling braking resistors (9; 19) by ventilating air, wherein the braking resistors (9; 19) are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat, wherein the arrangement comprises:

- a radial fan (7; 17),
- a plurality of braking resistors (9; 19) to be cooled,

characterised in that

- the fan (7; 17) is a radial fan (7; 17) adapted to deflect the air in different directions transverse to a rotating axis of the fan (7; 17),
- the plurality of braking resistors (9; 19) are arranged in at least some of the different directions,
- the rotating axis of the fan (7; 17) extends from top to bottom, or vice versa, so that, during operation of the arrangement, the cool air is guided from top to bottom to the fan (7; 17) and is deflected by the fan (7; 17) towards the plurality of the braking resistors (9; 19).

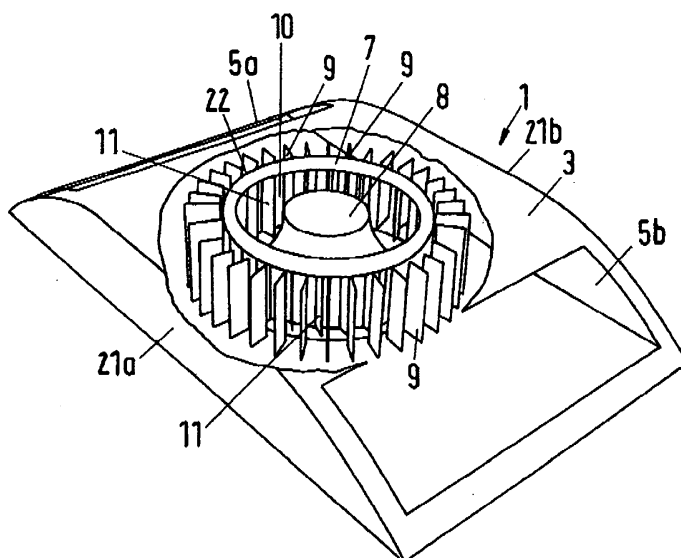


Fig. 2

Description

[0001] The invention relates to an arrangement for cooling braking resistors by ventilating air, wherein the braking resistors are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat. The invention also relates to a method of cooling braking resistors of a track bound vehicle. Furthermore, the invention relates to a track bound vehicle comprising the arrangement. In addition, the invention relates to a method of manufacturing a cooling arrangement for cooling braking resistors by ventilating air.

[0002] US 4,840,221 describes a device for ventilating braking rheostats in a locomotive which is powered electrically, by means of an internal combustion engine, or by a combination thereof. The rheostats are disposed in a layer close to the locomotive roof. The device includes at least one tangential fan having a horizontal axis which extends longitudinally relative to the locomotive and blowing air towards said rheostats. The device further includes air intake openings located in the side faces of the locomotive.

[0003] Since the tangential fans are located below the roof section of the locomotive's car body, the device cannot be used for trains having a distributed propulsion system. Such a distributed propulsion system usually comprises power converters at different locations of the train, including at locations of the train where passengers or goods should be transported. Especially in high speed trains, i.e. trains travelling at velocities higher than 250 km/h, such distributed propulsion systems are widely used. The power converters are adapted to provide electric propulsion motors with electric energy and, during braking, the power converters may produce electric energy by so-called dynamic braking which - at least under specific circumstances - cannot be fed back to the power network. The braking resistors for dissipating this electric energy should be placed in the vicinity of the power converter.

[0004] It may be possible to place several braking resistors in a row one after another within the roof section of a vehicle, in particular a train, such as a high speed train. Cooling air for cooling this row of braking resistors may be ventilated by a so-called axial fan. An axial fan accelerates air incoming along its rotational axis without significant deflection of the flow direction.

[0005] However, the cooling of a row of consecutive braking resistors has disadvantages. In particular, the last braking resistors in the row are not cooled as effectively as the first resistor in the row, since already heated air from the first resistors is used to cool the last resistors in the row. If the row extends in the direction of travel within the roof section of a train, the arrangement including the fan and the conduits for conducting the incoming and outgoing air requires a comparatively long section of the train. Furthermore, the pressure loss caused by conducting the cooling air along the braking resistors is

comparatively high. Therefore, the electric energy needed to operate the fan is not efficiently used. In addition, the comparatively high outlet temperature of the cooling air at the end of the row may be critical for safety reasons. Damages and injuries within the surrounding of the vehicle may be caused by the high temperature. Also, the noise production of an axial fan and of the ventilated air which passes the braking resistors to be cooled is high. If the rotational speed of the fan shall be reduced, it can be considered to increase the diameter of the fan. However, large diameters are not possible within the roof section of high speed trains.

[0006] High speed trains require maximum braking power at high speeds, since the kinetic energy is proportional to the square of the velocity. This means that especially high speed trains need highly effective cooling arrangements for their braking resistors, but the available space is small compared to other types of trains, since high speed trains have small aerodynamic resistance and, therefore, little space in the roof section.

[0007] It is an object of the present invention to provide an arrangement for cooling braking resistors by ventilating air, wherein the braking resistors are adapted to dissipate electric energy caused by braking a track bound vehicle, wherein the arrangement can be located in the roof section of the car body of the vehicle, wherein the production of noise is small and wherein a plurality of braking resistors can effectively be cooled.

[0008] It is a further object of the invention, to provide a corresponding track bound vehicle comprising the arrangement

[0009] It is also an object of the invention, to provide a method of cooling braking resistors of a track bound vehicle corresponding to the arrangement. Finally, it is an object of the present invention, to provide a method of manufacturing the cooling arrangement

[0010] According to a basic idea of the present invention, a radial fan is used to ventilate air for cooling a plurality of braking resistors.

[0011] Another expression which is used in practice for a radial fan is "centrifugal fan". A centrifugal fan is a fan which is provided with gas, in particular air, in the direction of the rotating axis of the fan. This incoming air is sucked by the fan to the interior of the circular arrangement of the fan blades. Instead of fan blades, other means for accelerating the gas or air can alternatively be used by the fan, for example ribs. The radial or centrifugal fan deflects the air in the interior of the circular arrangement in radial direction, wherein the velocity of the deflected gas or air has - in most cases - also a tangential component. "Radial" is referred to the rotational axis of the fan.

[0012] Centrifugal fans are widely known to be operated within a so-called squirrel cage. However, such a squirrel cage is not necessarily required for the present invention. Rather, it is intended that the radial fan accelerates the incoming air in different directions, namely different radial direction. This means, that the flow-density

of the ventilated air becomes significantly smaller than the flow-density of the incoming air which is sucked by the fan to the interior. One advantage of this is that the noise production caused by the air when it passes the braking resistors is small. Furthermore, many braking resistors which are arranged in the surrounding of the radial fan can be cooled. If a squirrel cage is used at all, it has several openings for passing the deflected air in different radial directions. However, it is preferred that no squirrel cage is used, but that the area between the fan and the surrounding in radial directions is open, i.e. not blocked by walls extending in the circumferential direction.

[0013] According to another aspect of the invention, the rotating axis of the fan extends from top to bottom, or vice versa. This means that the incoming air is sucked from top to bottom by the fan and is deflected mainly in horizontally extending radial directions of the fan. Therefore, the incoming air can be sucked through an inlet opening in the roof of the vehicle and can be conducted into the fan. Since the height of the fan having a vertical or nearly vertical rotating axis can be very small (e.g. smaller than 50 cm), and since the braking resistors to be cooled can be located at the same height level as the fan, the arrangement requires very little space in vertical direction. The roof section of high speed trains comprises sufficient space to accommodate the arrangement.

[0014] A radial fan comprises an interior region where the cool air is sucked into. Therefore, a suction conduct can be defined which conducts the air into and/or within this region. The conduct can be formed by the fan itself and/or by additional parts above the fan. A conduct within the region may be shaped to support redirection of the air flow from a vertical direction to horizontal directions.

[0015] In particular, the following is proposed:

[0016] An arrangement for cooling braking resistors by ventilating air, wherein the braking resistors are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat, wherein the arrangement comprises:

- a radial fan,
- a plurality of braking resistors to be cooled, wherein
- the fan is a radial fan adapted to deflect the air in different directions transverse to a rotating axis of the fan,
- the plurality of braking resistors are arranged in at least some of the different directions,
- the rotating axis of the fan extends from top to bottom, or vice versa, so that, during operation of the arrangement, the cool air is sucked from top to bottom into the fan and is deflected by the fan towards the plurality of the braking resistors.

[0017] According to a preferred embodiment of the arrangement, the plurality of braking resistors are located on opposite sides of the fan. Optionally, the plurality of

braking resistors are located around the periphery of the fan. Therefore, many braking resistors can be cooled by air from the same fan.

[0018] If a single fan is not sufficient to cool all required braking resistors, a further radial fan or more than one additional radial fan can be used. Again, it is preferred that the braking resistors to be cooled by the respective fan are arranged at least on opposite sides of the fan or around the periphery of the fan, wherein the braking resistors are located exactly or nearly at the same height level as the fan.

[0019] Any standard form of braking resistors can be used. For example, metal sheets having cut outs for passing the cooling air can be used. It is also possible that the braking resistors comprise fins or other protruding parts in order to increase the surface area where the cooling air can pass.

[0020] A suction conduct may extend above the fan and conducts the incoming air to the interior of the fan. It is possible, but not necessarily required, that the conduct comprises a canal having walls, for example a tube or hose. However, the conduct can alternatively be realized by other parts of the vehicle, such as parts of the roof and fixing parts for fixing the braking resistors and/or the fan.

[0021] Outlet opening for passing heated air from the plurality of braking resistors may be arranged on opposite sides of the vehicle, in particular on opposite sides of the roof of the vehicle. This embodiment especially applies to high speed trains where the maximum cooling power is required in the range of high velocities. When the vehicle is stopping, such as within a railway station, the heated air which exits the vehicle on the opposite sides may be sucked again through the inlet opening in the roof of the vehicle into the fan. On the other hand, this cannot happen when the vehicle is driving with high velocities.

[0022] Furthermore, not only the arrangement for cooling braking resistors and the vehicle comprising this arrangement belong to the invention, but also a method of cooling braking resistors of a track bound vehicle and a method of manufacturing the cooling arrangement. In particular, a method of cooling braking resistors of a track bound vehicle is proposed, in particular of a rail vehicle, wherein

- cool air is sucked by operating a radial fan, wherein a rotation axis of the fan extends from top to bottom, or vice versa,
- the cool air is sucked from above of the fan into the fan and is deflected by the fan in different directions transverse to the rotation axis,
- the deflected air is allowed to pass a plurality of the braking resistors located in at least some of the different directions thereby cooling the plurality of the braking resistors.

[0023] Furthermore, a method of manufacturing a

cooling arrangement is proposed for cooling braking resistors by ventilating air, wherein the braking resistors are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat, wherein the following is provided:

- a fan,
 - a suction conduct, which is arranged to conduct cool air from the ambient of the vehicle into the fan, or, alternatively or in addition to the suction conduct, an inlet opening in a cover at the air inlet side of the fan,
 - a plurality of braking resistors to be cooled, wherein
 - a radial fan is provided as the fan and the fan is arranged to deflect the air in different directions transverse to a rotating axis of the fan,
 - the plurality of braking resistors are arranged in at least some of the different directions,
 - the suction conduct and/or inlet opening is arranged above the fan,
 - the rotating axis of the fan extends from top to bottom, or vice versa,
- so that, during operation of the arrangement the cool air is guided from top to bottom into the fan and is deflected by the fan towards the plurality of the braking resistors.

[0024] Advantages of the invention may be summarized as follows:

- Due to a small height of the arrangement, the arrangement can be placed in the roof section of the vehicle, in particular the rail vehicle. The arrangement can be placed within the comparatively narrow confinements of the roof section of high speed trains.
- Noise production is reduced due to comparatively small (due to large cross-sectional area which is passed by the air) flow-densities of the cooling air passing the braking resistors.
- There is a large area in the periphery of the radial fan where braking resistors to be cooled can be placed. Therefore, each braking resistor in the periphery can be cooled by "fresh" cooling air, which has not been used to cool another braking resistor.
- If one radial fan is not sufficient to cool all braking resistors, another fan can be used and the respective braking resistors can be arranged in the periphery of this additional fan.
- Since the incoming air of the fan is deflected to different radial directions, the aerodynamic resistance is small and the operation of the fan can be performed with high energy efficiency.
- Despite the low flow-densities of the cooling air, comparatively high volume flow rates can be produced by the fan. Therefore, the cooling air is heated up to comparatively small elevated temperatures which increases the safety with respect to the surrounding of the vehicle.

[0025] Examples of the invention will be described with reference to the attached figures.

- Fig. 1 a three dimensional view on top of a roof section of a vehicle, in particular of high speed train,
- Fig 2 The arrangement shown in Fig. 1, wherein some parts of the roof cover are broken away to show details of a radial fan and braking resistors arranged in the periphery of the radial fan,
- Fig. 3 a cross section along line 11-11 in Fig. 1, wherein the cross section is a vertical cross section and wherein a region of the interior of the radial fan is broken away in order to illustrate the air flow,
- Fig. 4 a view from above onto another embodiment of a roof section having two radial fans, wherein the braking resistors to be cooled are omitted,
- Fig. 5 the arrangement of Fig. 4, wherein similarly to Fig. 2, some parts of the roof cover are broken away,
- Fig. 6 a variant of the arrangement shown in Figs. 1 and 2, where the braking resistors are arranged on opposite sides of the radial fan and
- Fig. 7 a roof section similar to the section shown in Fig. 6, wherein the braking resistors are also arranged on opposite sides of the radial fan, but are arranged in a different manner next to each other.

[0026] The roof sections 1 shown in Fig. 1 has a front end 21 a and a back end 21 b. The cover 3 of the roof section 1 is extending downwards at the opposite side of a radial fan 7 which is placed in the centre of the roof section 1. In the downwards extending sections of the cover 3, openings 5a, 5b in form of rectangular cutouts are provided to enable air to pass through. The opening 5a, 5b may be provided - other than shown in Fig. 1 - with a mesh or other inserts, so that the air may pass, but intrusion of bigger parts is avoided.

[0027] The radial fan comprises an axis of rotation (not shown in Fig. 1) which extends in vertical direction, e.g. from top to bottom in Fig. 1. The axis of rotation is also an axis of rotational symmetry of the radial fan and - in this specific embodiment - of the arrangement of braking resistors 9 which are arranged around the periphery of the radial fan 7.

[0028] The radial fan 7 comprises a plurality of blades 11 which cause - while the fan 7 is rotating about the axis of rotation - an airflow in radial direction to the axis of rotation. The air is sucked from above the fan 7 through an opening 22 in the cover 3 (which is also symmetric to

the axis of rotation in this specific embodiment). The air from above the fan 7 is passing the opening 22 and is entering the inner region of the fan 7. This process can be viewed best in the cross section of Fig. 3. The inner region is denoted by reference number 10. The air flow is indicated by arrows. As can be seen in Fig. 1 and Fig. 2, there is a body 8 in the inner region 10 which has a curved surface area at the circumference of the body 8. This curved surface area supports deflection of the air from the above the fan 7 into the radial direction.

[0029] The deflected air passes the blades 11 towards the braking resistors 9. Therefore, the braking resistors 9 are cooled by passing air. The air flow continues towards the openings 5a, 5b in the downwardly extending section of the cover 3 and exits the roof section 1 through the openings 5a, 5b. The body 8 in the inner region 10 of fan 7 is partly broken away in Fig. 3.

[0030] Figs. 4 and 5 show another roof section having two radial fans which are arranged one after the other in the longitudinal direction of the section. The longitudinal

[0031] Provided that the roof section of Figs. 4 and 5 has the same width as the roof section of Figs. 1 to 3, the outlet openings 15a, 15b of the roof sections of Figs. 4 and 5 are longer in longitudinal direction than the openings 5a, 5b of the roof section of Figs. 1 to 3. Therefore, the air which is deflected by the radial fan 17a, 17b in radial direction can leave the roof section within the shortest possible distance. However, the outlet openings 15a, 15b may be shorter in other embodiments or may be divided in two or more separate openings.

[0032] There is an inlet opening 22a, 22b corresponding to the inlet opening 22 of Figs. 1 to 3 each inlet opening 22a, 22b is directly located above the respective radial fan 17a, 17b and is - in this specific embodiment - rotationally symmetric to the axis of rotation of fan 17a, 17b. The inlet openings 22a, 22b are formed as cutouts of the cover 23 of the roof section.

[0033] The braking resistors to be cooled are not shown in Figs. 4 and 5. They can be arranged, similarly to Fig. 1 to 3, around the periphery of the radial fan 17a, 17b and/or they can be arranged in two groups on both sides of the radial fans 17a, 17b. Such groups may be arranged similarly to the arrangements of braking resistors shown in Figs. 6 and 7. However, Figs. 6 and 7 are referred to a single-fan roof section.

[0034] Fig. 6 shows the same arrangement as shown in Figs. 1 to 3 with the exception of the arrangement of the braking resistors to be cooled. In the arrangement shown in Fig. 6, the braking resistors 9 are aligned in two rows extending in longitudinal direction between the radial fan 7 and the outlet opening 5b. The same arrangement of braking air resistors is also placed on the opposite side of the radial fan 7 between the fan and the outlet opening 5a. This second group of braking resistors is not shown in Fig. 6.

[0035] Fig. 7 shows a similar arrangement as Fig. 6 but the row of braking resistors 19 differs from the two

rows of braking resistors 9 according to Fig. 6. There is only one row extending in longitudinal direction on both sides of the radial fan 7 in Fig. 7. The braking resistors 19 are tilted and are directly placed under the outlet opening 5b. The same or similar arrangement of braking resistors is placed near the outlet opening 5a on the opposite side of the fan 7. This second row of braking resistors is not shown in Fig. 7.

[0036] The term "braking resistors" is used in the description of the Figures. The term covers different embodiments, in particular braking resistors with and without additional bodies for improving the heat transfer from the braking resistor to the cooling area.

Claims

1. An arrangement for cooling braking resistors (9; 19) by ventilating air, wherein the braking resistors (9; 19) are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat, wherein the arrangement comprises:

- a radial fan (7; 17),
- a plurality of braking resistors (9; 19) to be cooled,

characterised in that

- the fan (7; 17) is a radial fan (7; 17) adapted to deflect the air in different directions transverse to a rotating axis of the fan (7; 17),
- the plurality of braking resistors (9; 19) are arranged in at least some of the different directions,
- the rotating axis of the fan (7; 17) extends from top to bottom, or vice versa, so that, during operation of the arrangement, the cool air is guided from top to bottom to the fan (7; 17) and is deflected by the fan (7; 17) towards the plurality of the braking resistors (9; 19).

2. The arrangement according to claim 1, wherein the plurality of braking resistors (9; 19) are located on opposite sides of the fan (7; 17).
3. The arrangement according to claim 1 or 2, wherein the plurality of braking resistors (9; 19) are located around the periphery of the fan (7; 17).
4. The arrangement of one of claims 1 - 3, wherein a suction conduct (10), adapted to conduct cool air from the ambient of the vehicle into the fan (7; 17) is arranged to conduct air from above the fan (7; 17).
5. The arrangement according to claim 4, wherein the suction conduct (10) is formed by the fan (7; 17).
6. A track bound vehicle, in particular a rail vehicle,

comprising the arrangement of one of the preceding claims, wherein the suction conduct (10) extends from an inlet opening in a roof (1) of the vehicle into the fan (7; 17).

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7. The vehicle of the preceding claim, wherein outlet openings for passing heated air from the plurality of braking resistors (9; 19) are arranged on opposite sides of the vehicle, in particular on opposite sides of the roof (13) of the vehicle.

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8. A method of cooling braking resistors (9; 19) of a track bound vehicle, in particular a rail vehicle, wherein

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- cool air is sucked by operating a radial fan (7; 17), wherein a rotation axis of the fan (7; 17) extends from top to bottom, or vice versa,
- the cool air is sucked from above of the fan (7; 17) into the fan (7; 17) and is deflected by the fan (7; 17) in different directions transverse to the rotation axis,
- the deflected air is allowed to pass a plurality of the braking resistors (9; 19) located in at least some of the different directions thereby cooling the plurality of the braking resistors (9; 19).

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9. The method of manufacturing a cooling arrangement for cooling braking resistors (9; 19) by ventilating air, wherein the braking resistors (9; 19) are adapted to dissipate electric energy caused by braking a track bound vehicle, in particular a rail vehicle, into heat, wherein the following is provided:

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- a fan (7; 17),
- a plurality of braking resistors (9; 19) to be cooled,

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characterised in that

- a radial fan (7; 17) is provided as the fan (7; 17) and the fan (7; 17) is arranged to deflect the air in different directions transverse to a rotating axis of the fan (7; 17),
- the plurality of braking resistors (9; 19) are arranged in at least some of the different directions,
- the rotating axis of the fan (7; 17) extends from top to bottom, or vice versa, so that, during operation of the arrangement the cool air is sucked from top to bottom to the fan (7; 17) and is deflected by the fan (7; 17) towards the plurality of the braking resistors (9; 19).

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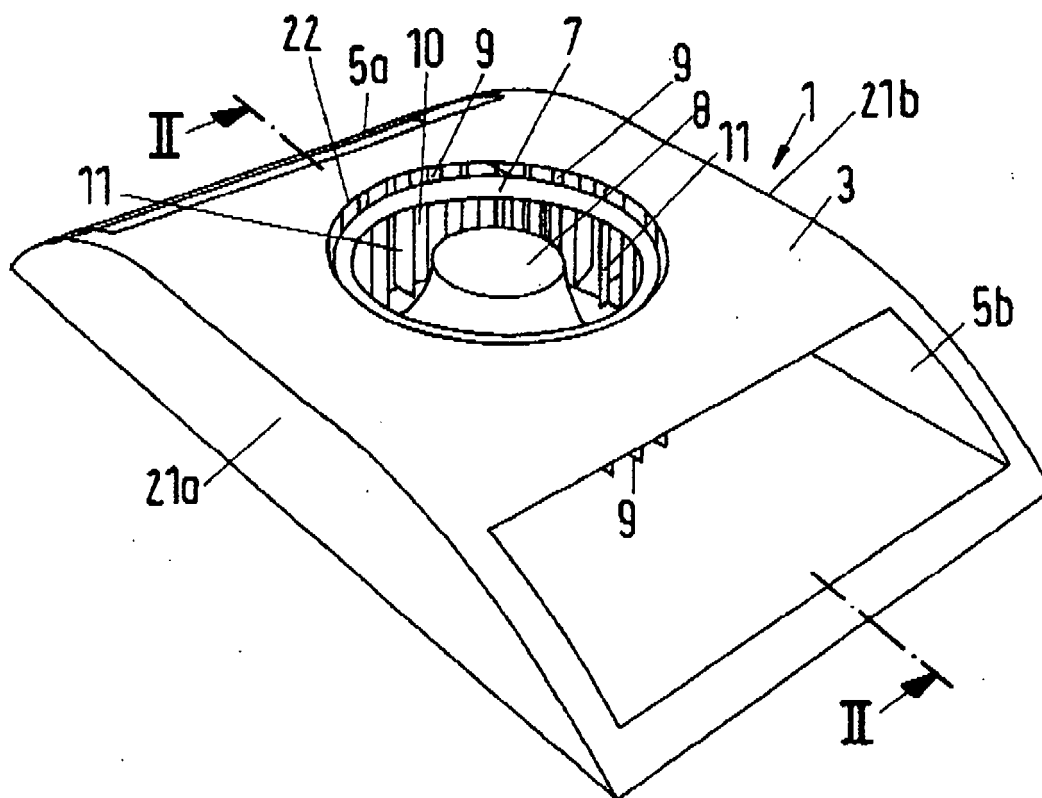


Fig.1

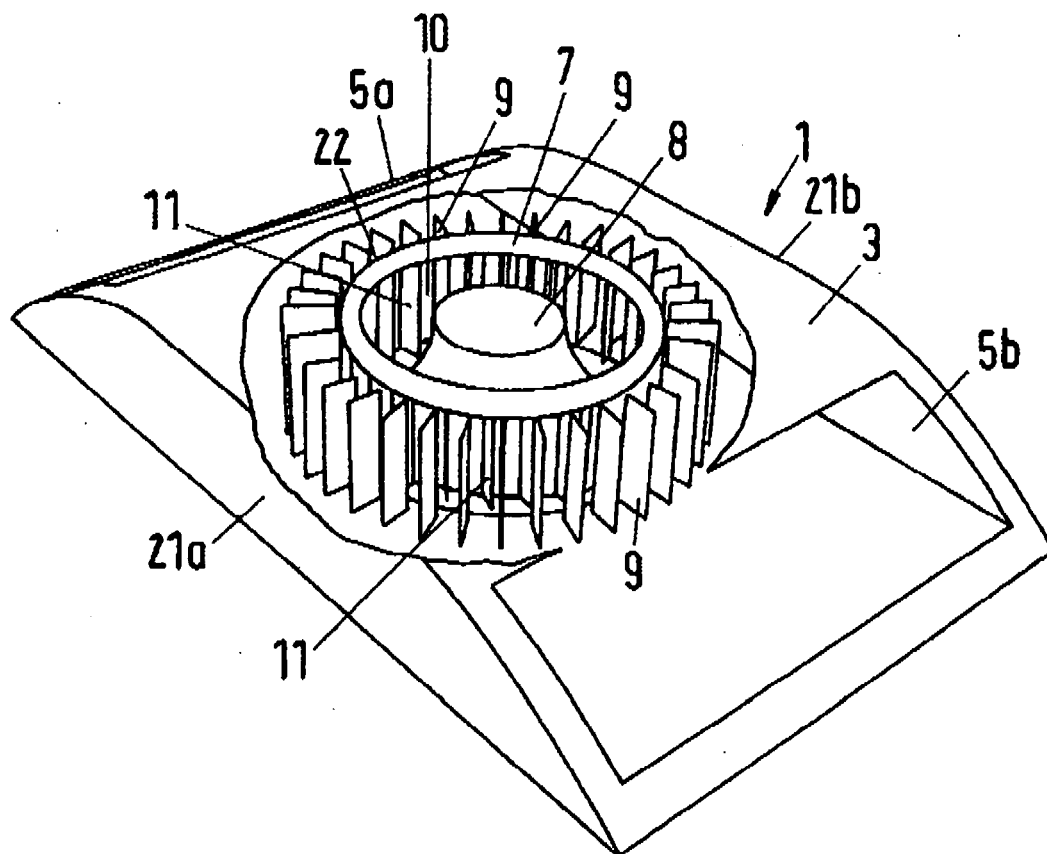


Fig. 2

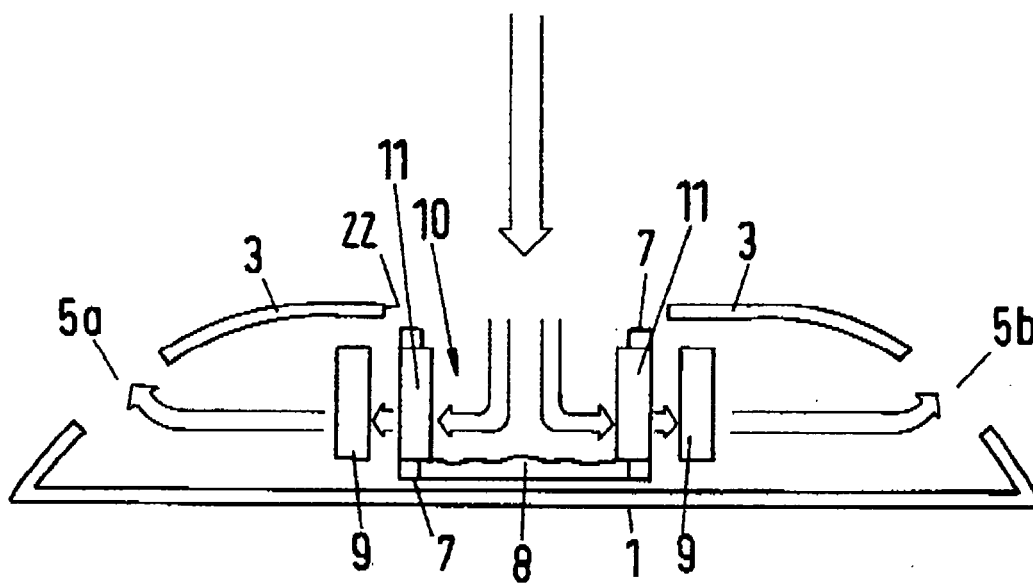


Fig.3
(II-II)

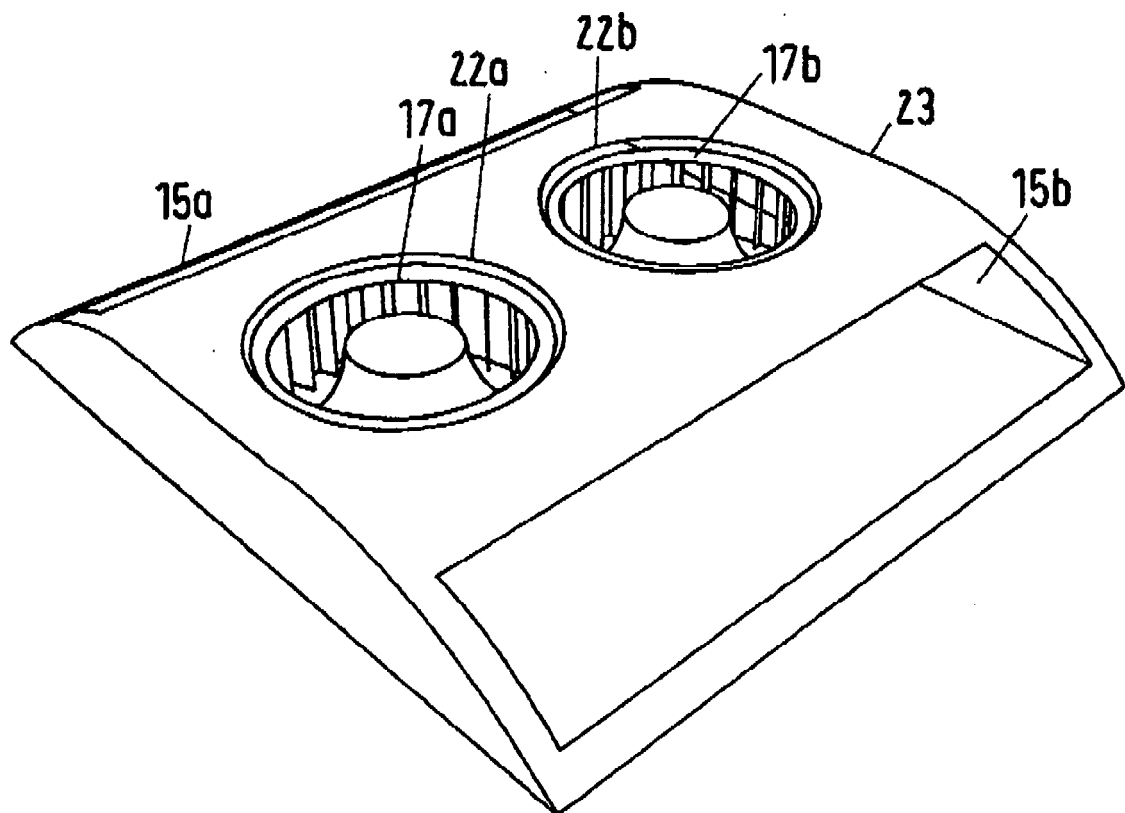


Fig. 4

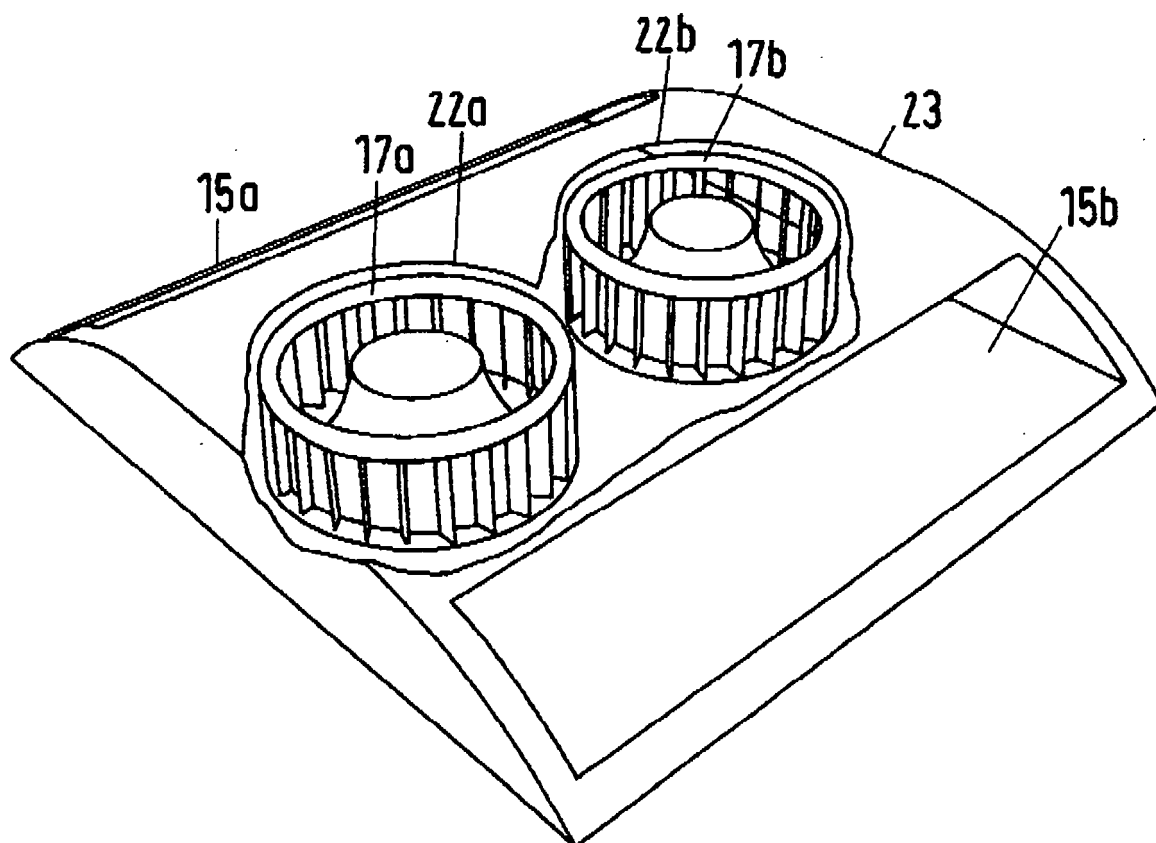


Fig.5

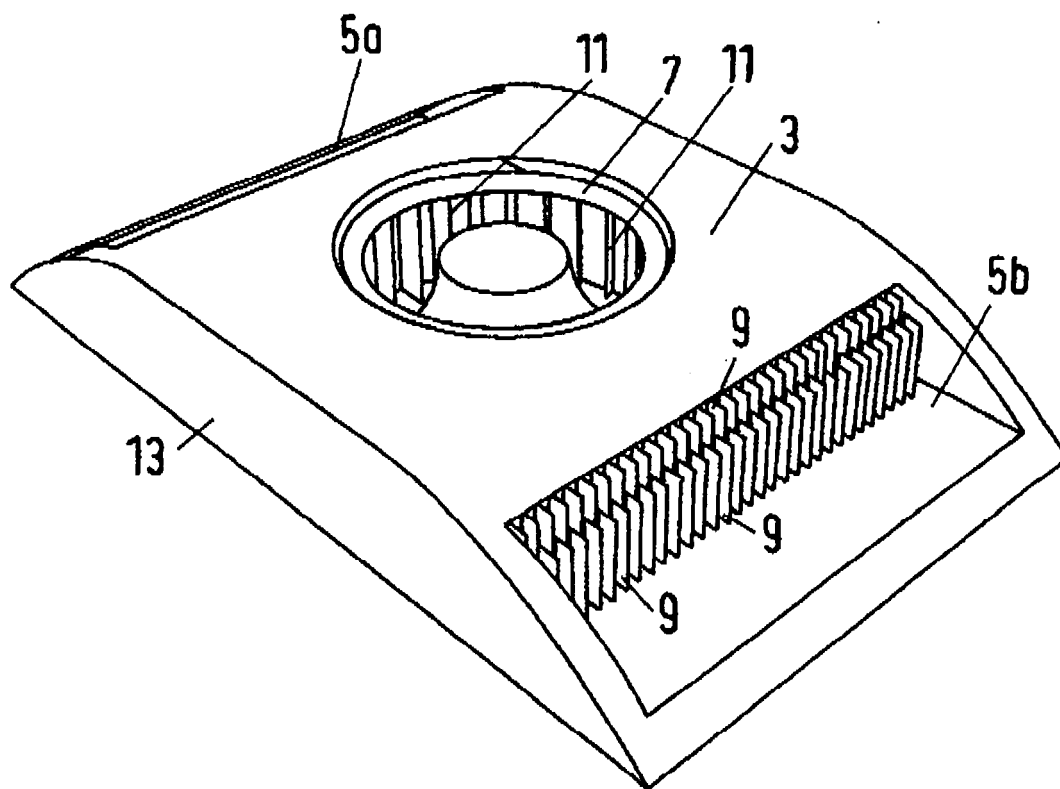


Fig.6

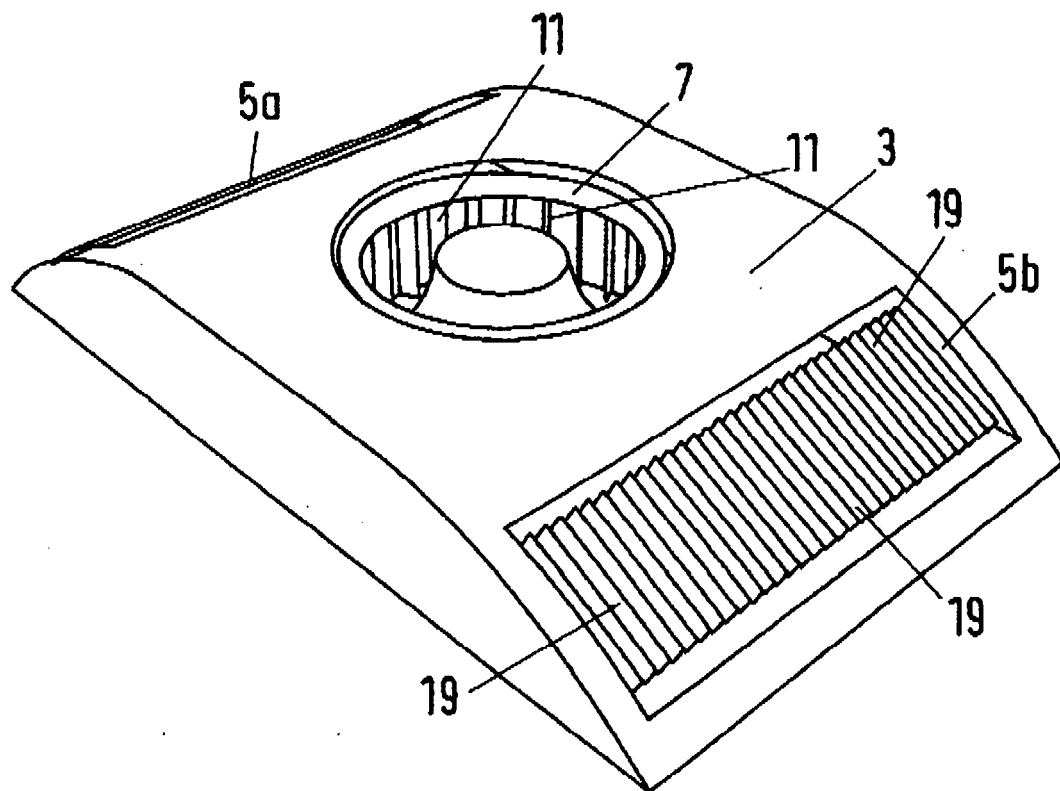


Fig.7



EUROPEAN SEARCH REPORT

Application Number
EP 09 01 2623

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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 T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 09 01 2623

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