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(54) **AIR PURIFYING APPARATUS, ROAD TUNNEL COMPRISING SAID AIR PURIFYING APPARATUS AND METHOD FOR PURIFYING AIR**

LUFTREINIGER, STRASSENTUNNEL MIT DIESEM LUFTREINIGER UND VERFAHREN ZUR LUFTREINIGUNG

APPAREIL DE PURIFICATION D'AIR, TUNNEL ROUTIER COMPRENANT LEDIT APPAREIL DE PURIFICATION D'AIR ET PROCÉDÉ DE PURIFICATION D'AIR

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(73) Proprietor: **Cirade**
4532 JS Terneuzen (NL)

(72) Inventor: **DE GRAAF, Silvester**
4532 JS Terneuzen (NL)

(74) Representative: **V.O.**
P.O. Box 87930
2508 DH Den Haag (NL)

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Description

[0001] The invention relates to an air purifying apparatus, in particular a passive air purifying apparatus, for along the roadside.

[0002] In general, along and in the vicinity of a roadside there is a relatively high concentration of pollution in the air compared to typical ambient air. This so-called roadside air, or polluted air comprises exhaust gases from traffic, such as greenhouse gases and particulate matter, which accumulate at and/or near the roadside. Depending on the surroundings, such as buildings, noise barriers and walls, it may be difficult for the polluted air to disperse. In particular, polluted air may linger in road tunnels. Therefore, in the vicinity of the roadside, environmental norms may be exceeded locally to the detriment of the environment and possibly to the health of road users and/or (local) residents.

[0003] Also, depending on the length of a road tunnel, polluted air may tend to accumulate at the entrance/exit of the tunnel relatively quickly and may often exceed environmental norms. Polluted air accumulates in the tunnel and is driven towards the entrance/exit by traffic exiting the tunnel. In particular, a vehicle that participates in or makes up the traffic causes a local disturbance in an ambient pressure field. This local disturbance or change in the ambient pressure field around the vehicle moves along with the vehicle and tends to drive polluted air comprising e.g. exhaust gasses and/or particulate matter towards the end of the tunnel, that is to say the entrance/exit in case of two-way tunnels. Vehicles with a relatively large frontal surface area, such as Sport Utility Vehicles (SUVs), busses, trucks and lorries, may relatively speaking contribute more to this phenomenon as they generally cause greater local changes in the pressure field around the vehicle than for instance cars or motorcycles. Consequently the aforementioned types of vehicles may cause a greater displacement of polluted air towards the end of the tunnel.

[0004] Active air purifying devices are generally known and typically applied in road tunnels. Commonly, active air purifying devices are required for ventilating road tunnels of a certain length, e.g. tunnels of at least 500 m in the Netherlands. In particular, national legislation requires active ventilation in case of traffic jams, which may cause a relatively fast accumulation of polluted air within the road tunnel. Also, these active air purifying devices are often required to actively dissipate and/or lead away smoke in case of a fire within the road tunnel, e.g. for safety or evacuation purposes. Typically, these active air purifying devices comprise an inlet, an outlet, an air duct extending therebetween, and a power source to power one or more ventilators that are provided in and/or along the air duct. This way, by controlling the speed of the ventilators, polluted air and/or smoke may be actively lead away from the road tunnel. Often, the ventilators of air purifying devices run at a stationary speed during normal use of the road tunnel. Such (continuous) operation of the active purifying devices may consume relatively much energy and can be relatively costly. Also, maintenance and/or replacement of the moving parts may be relatively costly and may disrupt the flow of traffic.

[0005] The invention aims at alleviating one or more of the aforementioned disadvantages. In particular, the invention aims to provide a passive air purifying apparatus that dissipates and/or disperses polluted air and does not require active ventilation. Thereby, the energy consumption and operational cost of the air purifying apparatus may be reduced with a relatively simple construction that may require low maintenance.

[0006] Documents WO 2009/058019 A1 and EP 1 632 607 A1 are directed to noise-protection along a roadside.

[0007] To that end, the invention provides for a passive air purifying apparatus for along the roadside according to claim 1.

[0008] An over-pressure in this context is an above-atmospheric pressure, wherein the atmospheric pressure is the environmental pressure prevailing at the roadside when no vehicles are passing. In addition, the over-pressure that is generated by a passing vehicle is meant to be construed as a local pressure increase in the flow field around the vehicle. In other words, a pressure accumulation at a side of the vehicle that faces the air flow that is incoming with respect to the vehicle. For example, as the vehicle moves through the air, the air is pushed aside by the vehicle and thereby the air flows around the vehicle. Due to the inertia of the air its pressure may increase locally causing the so-called over-pressure at the side of the vehicle that faces the direction of travel of the vehicle.

[0009] By positioning at least one inlet along a roadside with a one-way valve that is biased towards a closed position, it may effectively be counteracted that air flows out of the air duct. By configuring the bias such that the one-way valve opens when a valve pressure difference between a side of the one-way valve that faces away from the air duct and a side of the one-way valve that faces towards the air duct exceeds a threshold value, it may be facilitated that roadside air may enter the air duct through the at least one inlet under certain conditions whilst counteracting that air flows out of the air duct through the at least one inlet. When the threshold value is chosen such that an over-pressure generated by a passing vehicle leads to a valve pressure difference that is greater than the threshold value, roadside air may be fed into the air duct through the at least one inlet using the over-pressure generated by a passing vehicle. This way, roadside air, that is relatively polluted with respect to ambient air, may passively be dispelled from the roadside and be fed into the air duct. When the outlet is positioned remote from the roadside, it may be facilitated that roadside air that has been fed into the air duct may be expelled and/or dispersed out of the air duct remote from the roadside. Thereby, locally exceeding environmental norms may be counteracted cost-effectively using a relatively simple construction.

[0010] When the one-way valve comprises a flap for actuating the one-way valve from the closed to an open position, a construction that is relatively sensitive to over-pressure generated by passing vehicles may be achieved. This way, the flap may be used for actuating the one-way valve from the closed to an open position.

[0011] When the flap is connected to and/or forms part of a valve body which valve body engages a valve seat when being in the closed position, the valve body and/or flap may rest on the valve seat in the closed position. In particular, the valve seat may counteract that the valve body and/or flap moves past the valve seat toward the side of the one-way valve that faces away from the air duct. Advantageously, the flap may be configured for actuating the valve body to bring it from the closed to an open position. Thereto, the flap may be aerodynamically shaped to tailor its response to over-pressure generated by passing vehicles.

[0012] By providing the at least one outlet with a flue, air, in particular roadside air, may be transferred through the air duct to the external environment relatively effectively via the so-called stack-effect. Thereby, pollutants may be dispersed remotely which may reduce their impact on the (immediate) surroundings. This way, exceeding environmental norms locally along the roadside may be counteracted further.

[0013] When the at least one outlet, in particular an outlet of the flue, is placed at a distance from the roadside, preferably at an elevated position transverse to a plane of the roadside, pollutants may be dispersed at higher altitudes which may reduce their impact on the (immediate) surroundings. In particular, pollutants may be dispersed above the immediate surroundings, such as buildings or noise barriers. This may be especially beneficial in so-called street canyons in which a road or street is flanked by buildings on both sides creating a canyon-like environment. In addition, pollutants may be dispersed more effectively at higher altitudes where the so-called wind speed is generally higher relative to the wind speed at lower altitudes.

[0014] When the at least one outlet, in particular comprising the flue, is configured for passively generating an under-pressure in the air duct, passive transfer of roadside air from the at least one inlet to the at least one outlet via the air duct may be facilitated. In particular, by providing the at least one outlet and/or flue with e.g. a cap, cowl or so-called turbovent, the passive transfer of air may be facilitated using a relatively simple and cost-effective construction.

[0015] By providing a plurality of successive outlets, in particular comprising flues, that are placed at intervals along the air duct, it may be facilitated that a relatively large volume of air, in particular roadside air, may be dispersed remote from the roadside through the plurality of successive outlets.

[0016] By providing a plurality of interspaced inlets that are placed longitudinally along the air duct, a relatively large volume of air, in particular roadside air, may be fed into the air duct via the plurality of interspaced inlets to be dispersed remote from the roadside, e.g. through the at least one outlet.

[0017] Similarly, by providing a plurality of interspaced inlets that are placed transversely along the air duct, a relatively compact construction can be achieved whilst increasing the volume of air, in particular roadside air, that may be fed into the air duct via the plurality of interspaced inlets.

[0018] By providing at least one air guiding panel placed along the air duct that guides the airflow generated by passing vehicles toward and/or through the at least one inlet, a momentum of airflow may be led towards and generate a pressure difference at the inlet. This way, flow of air, in particular roadside air, towards and/or through the at least one inlet may be facilitated. Thereby, dissipation of polluted air away from the roadside and into the air duct may be facilitated. Additionally or alternatively, the at least one air guiding panel may be provided and/or formed as a so-called air scoop.

[0019] When the passive air purifying apparatus comprises at least one second inlet, at least one second outlet and a second air duct connecting the at least one second inlet with the at least one second outlet, wherein the at least one second outlet is positioned along the roadside and wherein the at least one second inlet positioned remote from the roadside, wherein the at least one second outlet is provided with an opposite one-way valve that is also biased towards a closed position, wherein the bias is such that the opposite one-way valve opens when a second valve pressure difference between a side of the opposite one-way valve that faces away from the air duct and a side of the opposite one-way valve that faces towards the second air duct exceeds a second threshold value, wherein the second threshold value is chosen such that an under-pressure generated at a trailing end of a passing vehicle leads to a second valve pressure difference that is, in particular in absolute sense, greater than the second threshold value, ambient air taken in remote from the roadside may be passively fed to the roadside. This way, polluted air at and/or near the roadside may be diluted with relatively clean ambient air. Thereby, locally exceeding environmental norms may be counteracted cost-effectively using a relatively simple construction.

[0020] An under-pressure in this context is a sub-atmospheric pressure, wherein again the atmospheric pressure is the environmental pressure prevailing at the roadside when no vehicles are passing. The under-pressure that is generated by a passing vehicle is meant to be construed as a local pressure decrease in the flow field around a vehicle. The local pressure decrease in the flow field usually occurs at a side of the vehicle that faces away from the direction of travel of the vehicle such as its trailing end and/or sides. In particular, relatively elongate vehicles, such as limousines, busses, trucks and lorries, may at their sides that are substantially parallel to the direction of travel of the vehicle generate a local pressure

decrease which may be further enhanced in e.g. road tunnels and street canyons.

[0021] Similarly, as discussed above for the flap, valve body and valve seat, similar advantages may apply mutatis mutandis for a second flap, second valve body and second valve seat, respectively.

[0022] By providing an air purifying filter that is arranged in the air duct, air, in particular roadside air, may be purified before it is dispersed through the at least one outlet remote from the roadside. Thereby, contributing to a more sustainable environment.

[0023] When the air purifying filter forms a passage that fluidly couples the air duct to the second air duct, thereby forming an air duct unit, air, in particular roadside air, purified by the air purifying filter may be returned to the roadside. Thereby, dilution of the roadside air may be facilitated using a relatively sustainable closed-loop system.

[0024] If the (opposite) one-way valve is segmented into a plurality of valve segments, wherein each valve segment is biased towards the closed position, a construction that is relatively sensitive to pressure differences may be realized. In addition, a degree of safety may be built in that may counteract the failure of an inlet and/or outlet.

[0025] The invention further provides for a road tunnel provided with a passive air purifying apparatus including features as discussed above and according to claim 10.

[0026] By dimensioning the air duct, in particular of the air purifying apparatus with the road tunnel, to accommodate at least one human and provide it with at least one entrance accessible from the roadside, it may be used as an escape route. When the air purifying device comprises an over-pressure ventilation device for actively generating an above-ambient pressure inside the air duct, clean air may be forced into the air duct to create an above-ambient pressure inside the air duct that is greater than the ambient pressure e.g. in the road tunnel or in the vicinity of the roadside. This way, the one-way valves may be kept closed in case of a fire. Thereby, smoke may be counteracted from entering the air duct in case of a fire. In this manner, at least part of an interior of the passive air purifying apparatus may contain clean air and have good visibility that provides a safe escape route for evacuating people as well as for emergency services.

[0027] The invention further provides for a method for passively purifying air along a roadside, according to claim 13, and comprising the steps of: providing a passive air purifying apparatus including features as discussed above, using a pressure difference generated by passing vehicles to open a one-way valve of an inlet to an air duct, wherein the one-way valve is biased towards a closed position, drawing air into the air duct through the inlet by passively generating an under-pressure in the air duct with an outlet of the air duct; and leading air away from along a road side and dispersing it into the atmosphere through the outlet. Advantageously, the method may further comprise the step of purifying the air within the air duct with a air purifying filter placed in the air duct. Such as for example arranging the air purifying filter along a wall of the air duct, inside the air duct or as a passage that fluidly connects the air ducts.

[0028] The invention will be further elucidated on the basis of exemplary embodiments which are represented in the drawings. The drawings are only schematic representations of embodiments of the invention, which are given by manner of non-limiting exemplary embodiments. In the drawings:

Fig. 1 shows a simplified schematic cross sectional view of a first embodiment of a passive air purifying apparatus according to the invention;
Fig. 2 shows a simplified schematic front view of a roadside with a schematic cross sectional view of a second embodiment of the passive air purifying apparatus according to the invention;
Fig. 3 shows a simplified schematic and partially cut away side view of a third embodiment of the passive air purifying apparatus according to the invention;
Fig. 4 shows a simplified schematic cross sectional view of a fourth embodiment of a passive air purifying apparatus according to the invention;
Fig. 5 shows a simplified schematic cross sectional side view of a fifth embodiment of the passive air purifying apparatus according to the invention; and
Fig. 6 shows a simplified schematic cross sectional front view of a road tunnel comprising a passive purifying air apparatus according to the invention.

[0029] In the Figures identical or corresponding parts are represented with the same reference numerals.

[0030] Fig. 1 shows a first embodiment of a passive air purifying apparatus 1 according to the invention. The passive air purifying apparatus 1 is placed along a roadside R. In particular, the passive air purifying apparatus 1 of the first embodiment is elegantly arranged in and/or as part of a guardrail. Additionally or alternatively, the passive air purifying apparatus 1 may be provided as a stand-alone device along the roadside R. The passive air purifying apparatus 1 comprises at least one inlet 2, at least one outlet 3 and an air duct 4. In this embodiment, one inlet 2 and one outlet 3 is shown. The air duct 4 connects the inlet 2 with the outlet 3. The inlet 2 is positioned along the roadside R. The outlet 3 is positioned remote from the roadside R. In the context of this application, remote is to be construed at least as facing away from the roadside R, in particular as at a distance, such as at least 5 m, 3 m, or 1 m, preferably at least 0.2 m and/or as at an elevation of 5 m, 3 m, or 1 m, preferably at least 0.1 m, above the surrounding buildings or structures or vegetation. The inlet 2 is provided with a one-way valve 5 that is biased towards a closed position I, see e.g. Fig. 3. The bias is such that the one-way valve 5 opens when a valve pressure difference between a side of the one-way valve 5 that faces away from the air duct 4 and a side of the one-way valve 5 that faces towards the air duct 4

exceeds a threshold value. The threshold value is chosen such that an over-pressure generated by a passing vehicle V (see e.g. Fig. 2) leads to a valve pressure difference that is greater than the threshold value. The threshold value is for example between 1 - 1000 Pa, such as between 1 - 750 Pa, 1 - 500 Pa, or 1 - 300 Pa .

[0031] Fig. 2 shows a second embodiment of the passive air purifying apparatus 1. In this case, the roadside R is surrounded by buildings that may counteract dispersion of the so-called roadside air or polluted air, which in turn may cause roadside pollution in the air to accumulate. In particular, the buildings may impede free flow of air, which is depicted schematically by the circulating arrow. The one-way valve 5 comprises a flap 6 for actuating the one-way valve 5 from the closed I to an open position II. As can be seen, the flap 6 forms a valve body 7. Additionally or alternatively, the flap 6 may be a separate component that is connected to the valve body 7 in a manner known to the person skilled in the art. In the closed position I, the valve body 7 engages a valve seat 8. As shown in Fig. 3 and Fig. 5, the valve body 7 and/or flap 6 rest on the valve seat 8 in the closed position I. The flap 6 is configured for actuating the valve body 7 to bring it from the closed position I to the open position II. Thereto, the flap 6 comprises a relatively large surface area, such as a surface area of for example 1 - 10000 cm^2, 10 - 5000 cm^2 or 25 - 1000 cm^2 . Additionally or alternatively, the flap 6 may be aerodynamically formed to tailor its response to over-pressure generated by passing vehicles V in a manner known to a person skilled in the art.

[0032] In the second embodiment, the outlet 3 comprises a flue 9. Each outlet 3 of the at least one outlet 3 may comprise a dedicated flue 9. Additionally or alternatively, a plurality of outlets 3 may as a group be in fluid connection with a single flue 9. An outlet of the flue 9 is placed at a distance from the roadside R, in particular at an elevated position H transverse to a plane of the roadside R. As shown in Fig. 2 the outlet of the flue 9 is preferably elevated above the surroundings, in particular the buildings, such that the roadside air may be dispersed at higher altitudes which reduces the impact on the (immediate) surroundings.

[0033] In Fig. 2, the outlet 3 is dimensioned such that it passively generates an under-pressure in the air duct 4. In particular, the outlet of the flue 9 is provided with a turbovent 10 contributing to the passively generated under-pressure in the air duct 4. Additionally or alternatively, the at least one outlet 3 and/or outlet of the flue 9 may e.g. comprise a cap, cowl and/or turbovent 10. Optionally, the air duct 4 may be configured for passively generating an under-pressure in a manner known to the person skilled in the art.

[0034] Fig. 3 shows a third embodiment of the passive air purifying apparatus 1. The passive air purifying apparatus 1 comprises air guiding panels 11 placed along the air duct 4 that guides the pressure difference generated by passing vehicles V towards and through the inlets 2. The inlets comprise a grid 23 that shields an interior of the air duct from solid particles, in particular solid particles sized in the range 1 - 50 mm. This way, entrance of e.g. pieces of asphalt or other solid particles that might damage the (interior of) the inlet 2 and/or the air duct 4 may be counteracted. The passive air purifying apparatus 1 further comprises an air purifying filter 12 that is arranged in the air duct 4. The outlet 3 corresponds to the outlet of the flue 9. As shown, the roadside air is filtered before it is expelled from the outlet 3.

[0035] Referring to Fig. 3, a plurality of interspaced inlets 3 are placed longitudinally along the air duct 4. In particular, the interspace between successive inlets 3 of the plurality of interspaced inlets 3 may e.g. be between 0.1 - 10 m, such as between 0.5 - 9 m, 1 - 8 m, or 2 - 5 m. Each inlet 3 is provided with a one-way valve 5 that is biased towards the closed position.

[0036] Fig. 4 shows a fourth embodiment of the passive air purifying apparatus 1. The passive air purifying apparatus 1 comprises a second inlet 13, a second outlet 14 and a second air duct 15 connecting the second inlet 13 with the second outlet 14. The second outlet 14 is positioned along the roadside R. The second inlet 13 is positioned remote from the roadside R. The second outlet 14 is provided with an opposite one-way valve 16 that is also biased towards a closed position I. The bias is such that the opposite one-way valve 16 opens when an absolute value of the second valve pressure difference between a side of the opposite one-way valve 16 that faces away from the second air duct 15 and a side of the opposite one-way valve 16 that faces towards the second air duct 15 exceeds a second threshold value. The second threshold value is chosen such that an under-pressure generated at a trailing end and/or side of a passing vehicle V leads to a second valve pressure difference that is greater than the second threshold value. The second threshold value may be proportional to or a multiple of the first threshold value.

[0037] The opposite one-way valve 16 comprises a second flap 17 for actuating the opposite one-way valve 16 from a closed I to an open position II. The second flap 17 forms a second valve body 18 which second valve body 18 engages a second valve seat 19 when being in the closed position I. The second flap 17 is configured for actuating the second valve body 18 to bring it from the closed I to the open position II.

[0038] Fig. 5 shows a fifth embodiment of the passive air purifying apparatus 1 comprising the air purifying filter 12. The air purifying filter 12 forms a passage that fluidly couples the air duct 4 to the second air duct 15, thereby forming an air duct unit 24.

[0039] Fig. 6 shows a road tunnel 20 provided with the passive air purifying apparatus 1. The depicted road tunnel 20 is a two-way tunnel. Passive air purifying apparatuses 1 are provided inside the tunnel 20, in particular along the side and upper-part of the tunnel 20. On the right-hand side of the road tunnel 20, a plurality of interspaced inlets 3 are placed transversely along the air duct 4. Each inlet 3 is provided with a one-way valve 5 that

is biased towards the closed position I. As can be seen, the vehicle V on the left side of the tunnel 20 causes the one-way valves 5 on the left-hand side to move to the open position II whilst the one-way valves 5 on the right-hand side remain substantially closed.

[0040] The passive air purifying apparatus 1 comprises at least one ventilator 21 for actively generating an above-ambient pressure inside the air duct to e.g. provide a safe passage there through with clean air and good visibility allowing people to use air duct 4 as an escape route 22 in case of fire. In this case, the air duct 4 is dimensioned such that humans may use it as escape route 22.

[0041] It will be clear to the skilled person that the invention is not limited to the exemplary embodiments represented here. Many variations are possible. For example, the passive air purifying apparatus may comprise alternating sections of air ducts and second air ducts. This way, inlets and second outlets may be conveniently disposed along the roadside to disperse roadside air whilst inducing an inflow of ambient air. Thereby, the over-pressure generated at a front face/leading edge and the under-pressure generated at the trailing end and/or side of passing vehicles may beneficially be utilized substantially simultaneously. Also, the road tunnel may additionally or alternatively be provided with second outlets associated with second air ducts for contributing to an inflow of ambient air to dilute the roadside air. For instance, inlets and/or outlets of the air purifying apparatus may be provided with a plurality of one-way valves. For example, the passive air purifying apparatus may comprise at least one ventilator for actively removing smoke from the tunnel in case of fire. Also, the air duct may be at least partially submerged and/or accommodated within the ground. Further, facades in/of buildings, in particular buildings along the roadside, may be provided with the passive air purifying apparatus without extending beyond the scope of the invention. Furthermore, additional one-way valves may be placed in the air duct to counteract backflow of air within the duct. Beneficially, the at least one outlet may be integrated in e.g. lampposts, electricity poles and/or (tele)communication masts. Advantageously, an energy generation device may be placed in the air duct for generating energy from the over-pressure generated from passing vehicles.

[0042] Further, the at least one air guiding panel and/or air scoop may extend from the inlet to direct the over-pressure generated by a passing vehicle towards the one-way valve. For example, each air guiding panel may have a cross section formed as an airfoil and/or a double curved airfoil. Said over-pressure may then be urged towards the one-way valve. For instance, the at least one air guiding panel and/or air scoop may be placed substantially parallel to the inlet to guide the airflow generated by passing vehicles toward and/or through the at least one inlet. This way, a momentum of airflow may be led towards and generate a pressure difference at the one-way valve in the inlet.

[0043] For example, a span of the airfoil shaped air guiding panel may extend along the longitudinal direction of the air duct. Further, a plurality of interspaced airfoil shaped air guiding panels may be placed longitudinally along the air duct, in particular such that each guiding panel corresponds to a respective inlet of the plurality of interspaced inlets that are placed longitudinally along the air duct. For instance, the span of the airfoil shaped air guiding panel may extend substantially transverse to the longitudinal direction of the air duct, in particular along a width direction of the air duct. This may be done in addition to or as an alternative to the longitudinally extending air guiding panels. The transversely extending air guiding panel may e.g. be positioned below an inlet facing towards a plane of the roadside to direct the over-pressure generated by passing vehicles towards said inlet. Additionally or alternatively, a free end of the air guiding panel or so-called wingtip of the airfoil shaped air guiding panel may e.g. be provided with a wingtip device or winglet. This way, wingtip vortices may be reduced and/or controllability of the airflow may be improved. This can facilitate feeding of roadside air into the air duct through the at least one inlet using the over-pressure generated by a passing vehicle .

[0044] Such variations shall be clear to the skilled person and are considered to fall within the scope of the invention as defined in the appended claims.

LIST OF REFERENCE

[0045]

1. Passive air purifying apparatus
2. Inlet
3. Outlet
4. Air duct
5. One-way valve
6. Flap
7. Valve body
8. Valve seat
9. Flue
10. Turbovent
11. Air guiding panel
12. Air purifying filter
13. Second inlet
14. Second outlet
15. Second air duct
16. Opposite one-way valve
17. Second flap
18. Second valve body
19. Second valve seat
20. Road tunnel
21. Ventilator
22. Escape route
23. Grid
24. Air duct unit

I. Closed position

II. Open position
R. Roadside
V. Vehicle

Claims

1. Passive air purifying apparatus (1) for along the roadside (R), comprising at least one first inlet (2), and at least one first outlet (3) and an air duct (4) connecting the at least one first inlet (2) with the at least one first outlet (3), wherein the at least one first inlet (2) is positioned along the roadside (R), wherein the at least one first outlet (3) is positioned remote from the roadside (R), wherein the first inlet (2) is provided with a one-way valve (5) that is biased towards a closed position (I), wherein the bias is such that the one-way valve (5) opens when a valve pressure difference between a side of the one-way valve (5) that faces away from the air duct (4) and a side of the one-way valve (5) that faces towards the air duct (4) exceeds a threshold value, wherein the threshold value is chosen such that an over-pressure generated by a passing vehicle (V) leads to a valve pressure difference that is greater than the threshold value, **characterized in that** said passive air purifying apparatus further comprising at least one second inlet, at least one second outlet and a second air duct (15) connecting the at least one second inlet with the at least one second outlet, wherein the at least one second outlet is positioned along the roadside (R) and wherein the at least one second inlet positioned remote from the roadside (R), wherein the at least one second outlet is provided with an opposite one-way valve (16) that is also biased towards a closed position (I), wherein the bias is such that the opposite one-way valve (16) opens when a second valve pressure difference between a side of the opposite one-way valve (16) that faces away from the second air duct (15) and a side of the opposite one-way valve (16) that faces towards the second air duct (15) exceeds a second threshold value, wherein the second threshold value is chosen such that an under-pressure generated by a passing vehicle (V) leads to a second valve pressure difference that is greater than the second threshold value.

2. Passive air purifying apparatus (1) according to claim 1,

wherein the one-way valve (5) comprises a flap for actuating the one-way valve (5) from the closed to an open position (II),
preferably wherein the flap is connected to and/or forms part of a valve body (7) which valve body engages a valve seat (8) when the one-way valve (5) is in the closed position (I), and said flap being configured for actuating the valve body (7) to bring it from the closed to an open position (II).

3. Passive air purifying apparatus (1) according to any of the preceding claims, wherein the at least one first outlet (3) comprises a flue (9).

4. Passive air purifying apparatus (1) according to any of the preceding claims,

wherein the at least one first outlet (3), in particular an outlet of the flue (9) of claim 3, is placed at a distance from a roadside (R), preferably at an elevated position transverse to a plane of the roadside (R); and/or
wherein the at least one first outlet (3), in particular comprising the flue (9) of claim 3, is configured for passively generating an under-pressure in the air duct (4), such as for example by comprising a cap, cowl and/or turbovent (10); and/or
wherein a plurality of successive first outlets (3), in particular flues (9) of claim 3, are placed at intervals along the air duct (4).

5. Passive air purifying apparatus (1) according to any of the preceding claims, wherein a plurality of inter-spaced first inlets (2) are placed along the air duct (4), for instance longitudinally or transversely, and wherein substantially each first inlet (2) is provided with a one-way valve (5) that is biased towards the closed position (I).

6. Passive air purifying apparatus (1) according to any of the preceding claims,

wherein the passive air purifying apparatus (1) comprises at least one air guiding panel (11) placed along the air duct (4) that guides the air flow generated by passing vehicles (V) towards and/or through the at least one first inlet (2); and/or
wherein the at least one first inlet (2) comprises a grid (23) that shields an interior of the air duct (4) from solid particles, in particular solid particles sized in the range 1 - 50 mm; and/or
wherein the air duct (4) is sectioned into a plurality of sections along its length.

7. Passive air purifying apparatus (1) according any of the preceding claims,

wherein the opposite one-way valve (16) comprises a second flap (17) for actuating the opposite one-way valve (16) from the closed position (I) to an open position (II),
preferably wherein the second flap (17) is connected to and/or forms part of a second valve body (18) which second valve body (18) en-

gages a second valve seat (19) when the opposite one-way valve (16) is in the closed position (I), and the second flap (17) is configured for actuating the second valve body (18) to bring it from the closed position (I) to an open position (II).

8. Passive air purifying apparatus (1) according to any of the preceding claims, further comprising an air purifying filter (12) that is arranged in the air duct (4), preferably wherein the air purifying filter (12) forms a passage that fluidly couples the air duct (4) to the second air duct (15) of claim 7, thereby forming an air duct unit (24).

9. Passive air purifying apparatus (1) according to any of the preceding claims, wherein the one-way valve (5) comprises a plurality of valve segments, wherein each valve segment is biased towards the closed position (I).

10. Road tunnel (20) provided with a passive air purifying apparatus (1) according to any of the preceding claims.

11. Road tunnel according (20) to claim 10, wherein the air duct (4) is dimensioned to accommodate at least one human, and wherein said air duct (4) is provided with at least one entrance accessible from the roadside (R).

12. Road tunnel according to claim 11, wherein the air purifying device (1) comprises an over-pressure ventilation device (21) for actively generating an above-ambient pressure inside the air duct (4).

13. Method for passively purifying air along a roadside (R), the method comprising the steps of:

- providing a passive air purifying apparatus (1) according to any one of claims 1-9:
- using a pressure difference generated by passing vehicles (V) to open a one-way valve of a first inlet (2) to an air duct (4), wherein the one-way valve (5) is biased towards a closed position (I);
- drawing air into the air duct (4) through the first inlet (2) by passively generating an under-pressure in the air duct (4) with a first outlet (3) of the air duct (4); and
- leading air away from along a roadside (R) and dispersing it into the atmosphere through the first outlet (3).

14. Method of claim 13, further comprising the step of:

- purifying the air within the air duct (4) with an air purifying filter (12) placed in the air duct (4).

Patentansprüche

1. Passive Luftreinigungseinrichtung (1) für entlang des Straßenrands (R), umfassend mindestens einen ersten Einlass (2) und mindestens einen ersten Auslass (3) und einen Luftkanal (4), der den mindestens einen ersten Einlass (2) mit dem mindestens einen ersten Auslass (3) verbindet, wobei der mindestens eine erste Einlass (2) entlang des Straßenrands (R) positioniert ist, wobei der mindestens eine erste Auslass (3) vom Straßenrand (R) entfernt positioniert ist, wobei der erste Einlass (2) mit einem Einwegventil (5) versehen ist, das in Richtung einer geschlossenen Position vorgespannt ist (I), wobei die Vorspannung derart ist, dass sich das Einwegventil (5) öffnet, wenn eine Ventildruckdifferenz zwischen einer dem Luftkanal (4) abgewandten Seite des Einwegventils (5) und einer dem Luftkanal (4) zugewandten Seite des Einwegventils (5) einen Schwellenwert überschreitet, wobei der Schwellenwert so gewählt ist, dass ein von einem vorbeifahrenden Fahrzeug erzeugter Überdruck (V) zu einer Ventildruckdifferenz führt, die größer als der Schwellenwert ist, **dadurch gekennzeichnet, dass** die passive Luftreinigungseinrichtung ferner mindestens einen zweiten Einlass, mindestens einen zweiten Auslass und einen zweiten Luftkanal (15) umfasst, der den mindestens einen zweiten Einlass mit dem mindestens einen zweiten Auslass verbindet, wobei der mindestens eine zweite Auslass entlang des Straßenrands (R) positioniert ist und wobei der mindestens eine zweite Einlass von dem Straßenrand (R) entfernt positioniert ist, wobei der mindestens eine zweite Auslass mit einem gegenüberliegenden Einwegventil (16) versehen ist, das ebenfalls in Richtung einer geschlossenen Position (I) vorgespannt ist, wobei die Vorspannung derart ist, dass sich das gegenüberliegende Einwegventil (16) öffnet, wenn eine zweite Ventildruckdifferenz zwischen einer vom zweiten Luftkanal (15) abgewandten Seite des gegenüberliegenden Einwegventils (16) und einer dem zweiten Luftkanal (15) zugewandten Seite des gegenüberliegenden Einwegventils (16) einen zweiten Schwellenwert überschreitet, wobei der zweite Schwellenwert so gewählt ist, dass ein von einem vorbeifahrenden Fahrzeug erzeugter Unterdruck (V) zu einer zweiten Ventildruckdifferenz führt, die größer als der zweite Schwellenwert ist.

2. Passive Luftreinigungseinrichtung (1) nach Anspruch 1,

wobei das Einwegventil (5) eine Klappe zum Betätigen des Einwegventils (5) von der geschlossenen in eine offene Position (II) umfasst, wobei die Klappe vorzugsweise mit einem Ventilkörper (7) verbunden ist und/oder einen Teil

davon bildet, wobei der Ventilkörper in einen Ventilsitz (8) eingreift, wenn das Einwegventil (5) in der geschlossenen Position (I) ist, wobei die Klappe dazu konfiguriert ist, den Ventilkörper (7) zu betätigen, um ihn von der geschlossenen in eine offene Position (II) zu bringen.

3. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche, wobei der mindestens eine erste Auslass (3) einen Schornstein (9) umfasst.

4. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche,

wobei der mindestens eine erste Auslass (3), insbesondere ein Auslass des Schornsteins (9) nach Anspruch 3, in einem Abstand zu einem Straßenrand (R), vorzugsweise an einer erhöhten Position quer zu einer Ebene des Straßenrands (R), angeordnet ist; und/oder
wobei der mindestens eine erste Auslass (3), insbesondere umfassend den Schornstein (9) nach Anspruch 3, zum passiven Erzeugen eines Unterdrucks im Luftkanal (4) konfiguriert ist, beispielsweise indem er eine Kappe, Haube und/oder einen Turbovent (10) umfasst; und/oder
wobei eine Mehrzahl an aufeinanderfolgenden ersten Auslässen (3), insbesondere Schornsteinen (9) nach Anspruch 3, in Abständen entlang des Luftkanals (4) angeordnet sind.

5. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche, wobei eine Mehrzahl an voneinander beabstandeten ersten Einlässen (2) entlang des Luftkanals (4), beispielsweise längs oder quer, angeordnet sind, und wobei im Wesentlichen jeder erste Einlass (2) mit einem Einwegventil (5) versehen ist, das in Richtung der geschlossenen Position (I) vorgespannt ist.

6. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche,

wobei die passive Luftreinigungseinrichtung (1) mindestens ein entlang des Luftkanals (4) angeordnetes Luftleitblech (11) umfasst, das den von vorbeifahrenden Fahrzeugen (V) erzeugten Luftstrom in Richtung des mindestens einen ersten Einlasses (2) und/oder durch ihn hindurch leitet; und/oder
wobei der mindestens eine erste Einlass (2) ein Gitter (23) umfasst, das ein Inneres des Luftkanals (4) gegenüber festen Partikeln, insbesondere festen Partikeln mit einer Größe im Bereich von 1-50 mm, abschirmt; und/oder
wobei der Luftkanal (4) entlang seiner Länge in eine Mehrzahl an Abschnitten unterteilt ist.

7. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche,

wobei das gegenüberliegende Einwegventil (16) eine zweite Klappe (17) zum Betätigen des gegenüberliegenden Einwegventils (16) von der geschlossenen Position (I) in eine offene Position (II) umfasst,
wobei die zweite Klappe (17) vorzugsweise mit einem zweiten Ventilkörper (18) verbunden ist und/oder einen Teil davon bildet, wobei der zweite Ventilkörper (18) in einen zweiten Ventilsitz (19) eingreift, wenn das gegenüberliegende Einwegventil (16) in der geschlossenen Position (I) ist, und die zweite Klappe (17) dazu konfiguriert ist, den zweiten Ventilkörper (18) zu betätigen, um ihn von der geschlossenen Position (I) in eine offene Position (II) zu bringen.

8. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche, ferner umfassend ein im Luftkanal (4) angeordnetes Luftreinigungsfilter (12),
wobei das Luftreinigungsfilter (12) vorzugsweise einen Durchgang bildet, der den Luftkanal (4) fluidisch mit dem zweiten Luftkanal (15) nach Anspruch 7 verbindet, dadurch eine Luftkanaleinheit (24) bildend.

9. Passive Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche, wobei das Einwegventil (5) eine Mehrzahl an Ventilsegmenten umfasst, wobei jedes Ventilsegment in Richtung der geschlossenen Position (I) vorgespannt ist.

10. Straßentunnel (20), versehen mit einer passiven Luftreinigungseinrichtung (1) nach einem der vorstehenden Ansprüche.

11. Straßentunnel (20) nach Anspruch 10, wobei der Luftkanal (4) so bemessen ist, dass er mindestens einen Menschen aufnehmen kann, und wobei der Luftkanal (4) mit mindestens einem vom Straßenrand (R) zugänglichen Eingang versehen ist.

12. Straßentunnel nach Anspruch 11, wobei die Luftreinigungseinrichtung (1) eine Überdruckbelüftungseinrichtung (21) zur aktiven Erzeugung eines über dem Umgebungsdruck liegenden Drucks innerhalb des Luftkanals (4) umfasst.

13. Verfahren zur passiven Reinigung der Luft entlang eines Straßenrands (R), wobei das Verfahren die folgenden Schritte umfasst:

- Bereitstellen einer passiven Luftreinigungseinrichtung (1) nach einem der Ansprüche 1 bis 9;
- Nutzen einer Druckdifferenz, erzeugt durch

vorbeifahrende Fahrzeuge (V), zum Öffnen eines Einwegventils eines ersten Einlasses (2) zu einem Luftkanal (4), wobei das Einwegventil (5) in Richtung einer geschlossenen Position (I) vorgespannt ist;
- Einziehen von Luft in den Luftkanal (4) durch den ersten Einlass (2) durch passives Erzeugen eines Unterdrucks im Luftkanal (4) mit einem ersten Auslass (3) des Luftkanals (4); und
- Abführen von Luft entlang eines Straßenrands (R) und Verteilen in die Atmosphäre durch den ersten Auslass (3).

14. Verfahren nach Anspruch 13, ferner umfassend den Schritt:

- Reinigen der Luft im Luftkanal (4) mit einem im Luftkanal (4) platzierten Luftreinigungsfilter (12).

Revendications

1. Appareil de purification d'air passif (1) pour le bord de route (R), comprenant au moins une première entrée (2), et au moins une première sortie (3) et un conduit d'air (4) reliant la ou les premières entrées (2) à la ou aux premières sorties (3), la ou les premières entrées (2) étant positionnées le long du bord de route (R), la ou les premières sorties (3) étant positionnées à distance du bord de route (R), la première entrée (2) étant pourvue d'une valve unidirectionnelle (5) qui est sollicitée vers une position fermée (I), la sollicitation étant telle que la valve unidirectionnelle (5) s'ouvre lorsqu'une différence de pression de valve entre un côté de la valve unidirectionnelle (5) qui est opposé au conduit d'air (4) et un côté de la valve unidirectionnelle (5) qui est tourné vers le conduit d'air (4) dépasse une valeur seuil, la valeur seuil étant choisie de telle sorte qu'une surpression générée par un véhicule passant (V) conduise à une différence de pression de valve qui est supérieure à la valeur seuil, **caractérisé en ce que** ledit appareil de purification d'air passif comprenant en outre au moins une seconde entrée, au moins une seconde sortie et un second conduit d'air (15) reliant la ou les secondes entrées à la ou les secondes sorties, la ou les secondes sorties étant positionnées le long du bord de la route (R) et la ou les secondes entrées étant positionnées à distance du bord de la route (R), la ou les secondes sorties étant pourvues d'une valve unidirectionnelle opposée (16) qui est également sollicitée vers une position fermée (I), la sollicitation étant telle que la valve unidirectionnelle opposée (16) s'ouvre lorsqu'une seconde différence de pression de valve entre un côté de la valve unidirectionnelle opposée (16) qui est opposé au second conduit d'air (15) et un côté de la valve unidirectionnelle opposée (16) qui est tourné vers le second conduit d'air (15) dépasse une seconde valeur seuil, la seconde valeur seuil étant choisie de telle sorte qu'une sous-pression générée par un véhicule passant (V) conduise à une seconde différence de pression de valve qui est supérieure à la seconde valeur seuil.

2. Appareil de purification d'air passif (1) selon la revendication 1,

dans lequel la valve unidirectionnelle (5) comprend un volet pour actionner la valve unidirectionnelle (5) de la position fermée à une position ouverte (II),
de préférence dans lequel le volet est relié à et/ou fait partie d'un corps de valve (7) lequel corps de valve s'engage dans un siège de valve (8) lorsque la valve unidirectionnelle (5) est dans la position fermée (I), et ledit volet étant configuré pour actionner le corps de valve (7) pour l'amener de la position fermée à une position ouverte (II).

3. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes, dans lequel la ou les premières sorties (3) comprennent un conduit de fumée (9).

4. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes,

dans lequel la ou les premières sorties (3), en particulier une sortie du conduit de fumée (9) selon la revendication 3, sont placées à distance d'un bord de route (R), de préférence à une position élevée transversalement à un plan du bord de route (R) ; et/ou
dans lequel la ou les premières sorties (3), en particulier comprenant le conduit de fumée (9) selon la revendication 3, sont configurées pour générer passivement une sous-pression dans le conduit d'air (4), comme par exemple en comprenant un capuchon, un capot et/ou un ventilateur à turbine (10) ; et/ou
dans lequel une pluralité de premières sorties successives (3), en particulier des conduits de fumée (9) selon la revendication 3, sont placées à intervalles le long du conduit d'air (4).

5. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes, dans lequel une pluralité de premières entrées (2) espacées sont placées le long du conduit d'air (4), par exemple longitudinalement ou transversalement, et dans lequel sensiblement chaque première entrée (2) est pourvue d'une valve unidirectionnelle (5) qui est sollicitée vers la position fermée (I).

6. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes,

dans lequel l'appareil de purification d'air passif (1) comprend au moins un panneau de guidage d'air (11) placé le long du conduit d'air (4) qui guide le flux d'air généré par le passage de véhicules (V) vers et/ou à travers la ou les premières entrées (2) ; et/ou
dans lequel la ou les premières entrées (2) comprennent une grille (23) qui protège l'intérieur du conduit d'air (4) des particules solides, en particulier des particules solides de taille comprise entre 1 et 50 mm ; et/ou
dans lequel le conduit d'air (4) est divisé en une pluralité de sections sur sa longueur.

7. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes,

dans lequel la valve unidirectionnelle opposée (16) comprend un second volet (17) pour actionner la valve unidirectionnelle opposée (16) de la position fermée (I) à une position ouverte (II),
de préférence dans lequel le second volet (17) est relié à et/ou fait partie d'un second corps de valve (18), lequel second corps de valve (18) vient en prise avec un second siège de valve (19) lorsque la valve unidirectionnelle opposée (16) est dans la position fermée (I), et le second volet (17) est configuré pour actionner le second corps de valve (18) pour l'amener de la position fermée (I) à une position ouverte (II).

8. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes, comprenant en outre un filtre de purification d'air (12) qui est disposé dans le conduit d'air (4), de préférence dans lequel le filtre de purification d'air (12) forme un passage qui relie de manière fluidique le conduit d'air (4) au second conduit d'air (15) selon la revendication 7, formant ainsi une unité de conduit d'air (24).

9. Appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes, dans lequel la valve unidirectionnelle (5) comprend une pluralité de segments de valve, chaque segment de valve étant sollicité vers la position fermée (I).

10. Tunnel routier (20) pourvu d'un appareil de purification d'air passif (1) selon l'une quelconque des revendications précédentes.

11. Tunnel routier (20) selon la revendication 10, dans lequel le conduit d'air (4) est dimensionné pour accueillir au moins un humain, et dans lequel ledit conduit d'air (4) est pourvu d'au moins une entrée accessible depuis le bord de la route (R).

12. Tunnel routier selon la revendication 11, dans lequel le dispositif de purification d'air (1) comprend un dispositif de ventilation à surpression (21) pour générer activement une pression supérieure à la pression ambiante à l'intérieur du conduit d'air (4).

13. Procédé de purification passive de l'air le long d'un bord de route (R), le procédé comprenant les étapes consistant à :

- fournir un appareil de purification d'air passif (1) selon l'une quelconque des revendications 1 à 9 :
- utiliser une différence de pression générée par le passage de véhicules (V) pour ouvrir une valve unidirectionnelle d'une première entrée (2) vers un conduit d'air (4), la valve unidirectionnelle (5) étant sollicitée vers une position fermée (I) ;
- aspirer de l'air dans le conduit d'air (4) par la première entrée (2) en générant passivement une sous-pression dans le conduit d'air (4) avec une première sortie (3) du conduit d'air (4) ; et
- évacuer l'air le long d'un bord de route (R) et le disperser dans l'atmosphère par la première sortie (3).

14. Procédé selon la revendication 13, comprenant en outre l'étape consistant à :
purifier l'air à l'intérieur du conduit d'air (4) avec un filtre purificateur d'air (12) placé dans le conduit d'air (4).

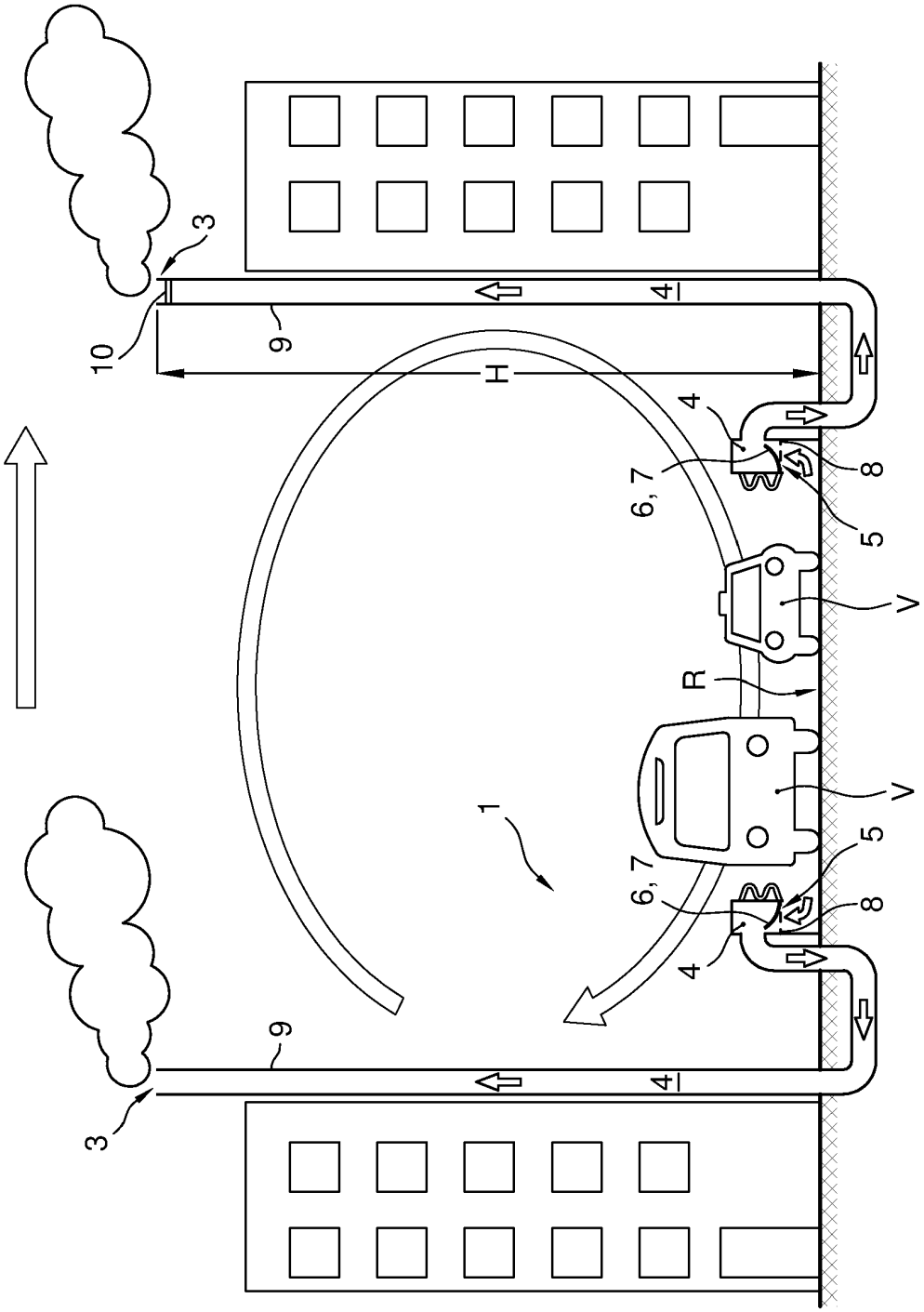


FIG. 2

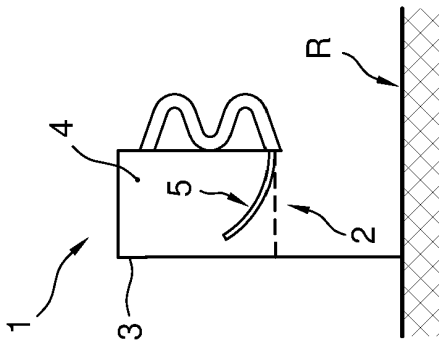


FIG. 1

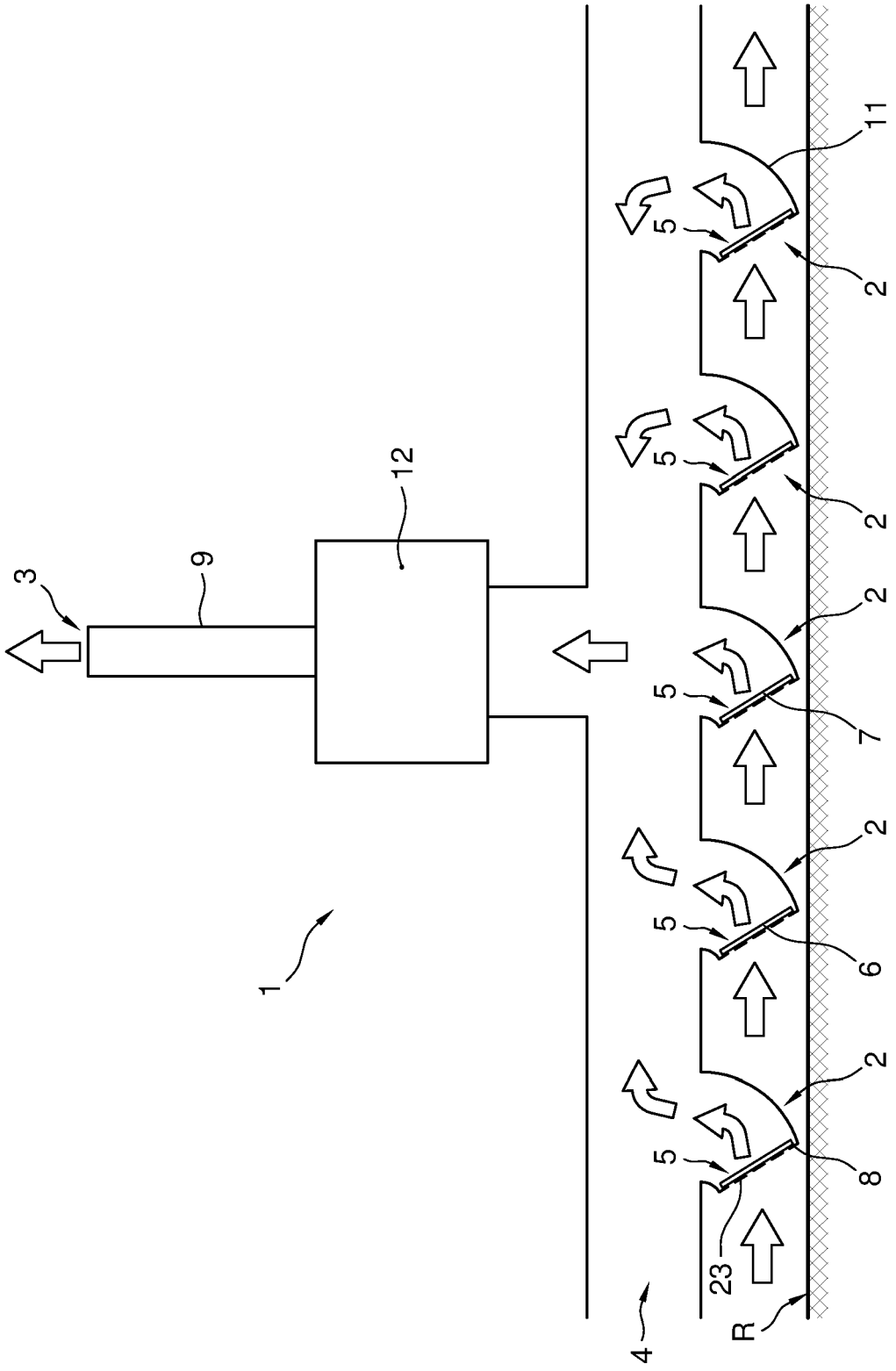
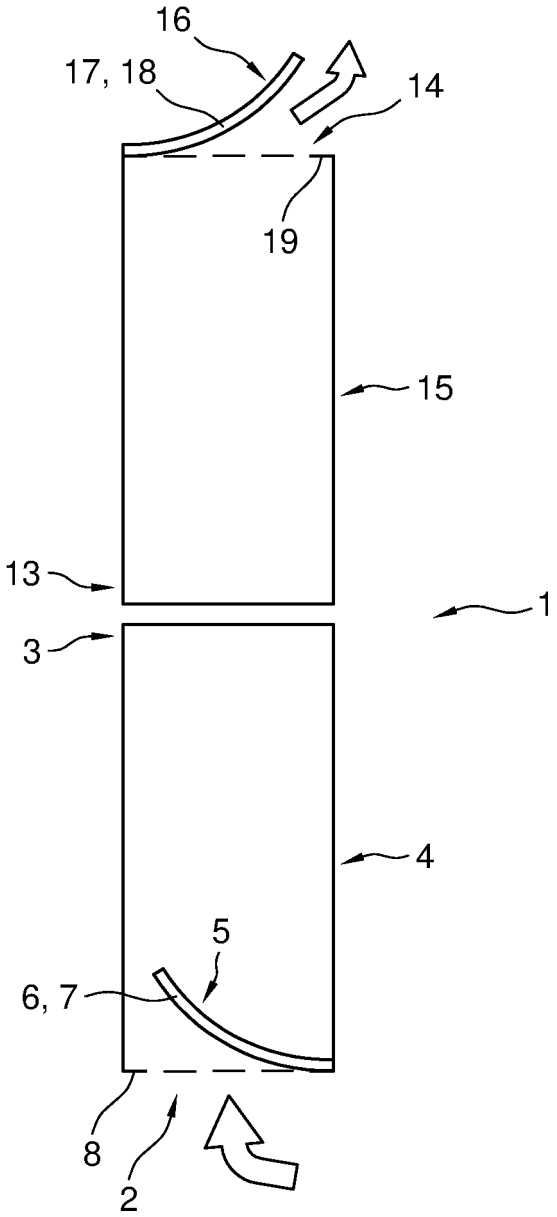
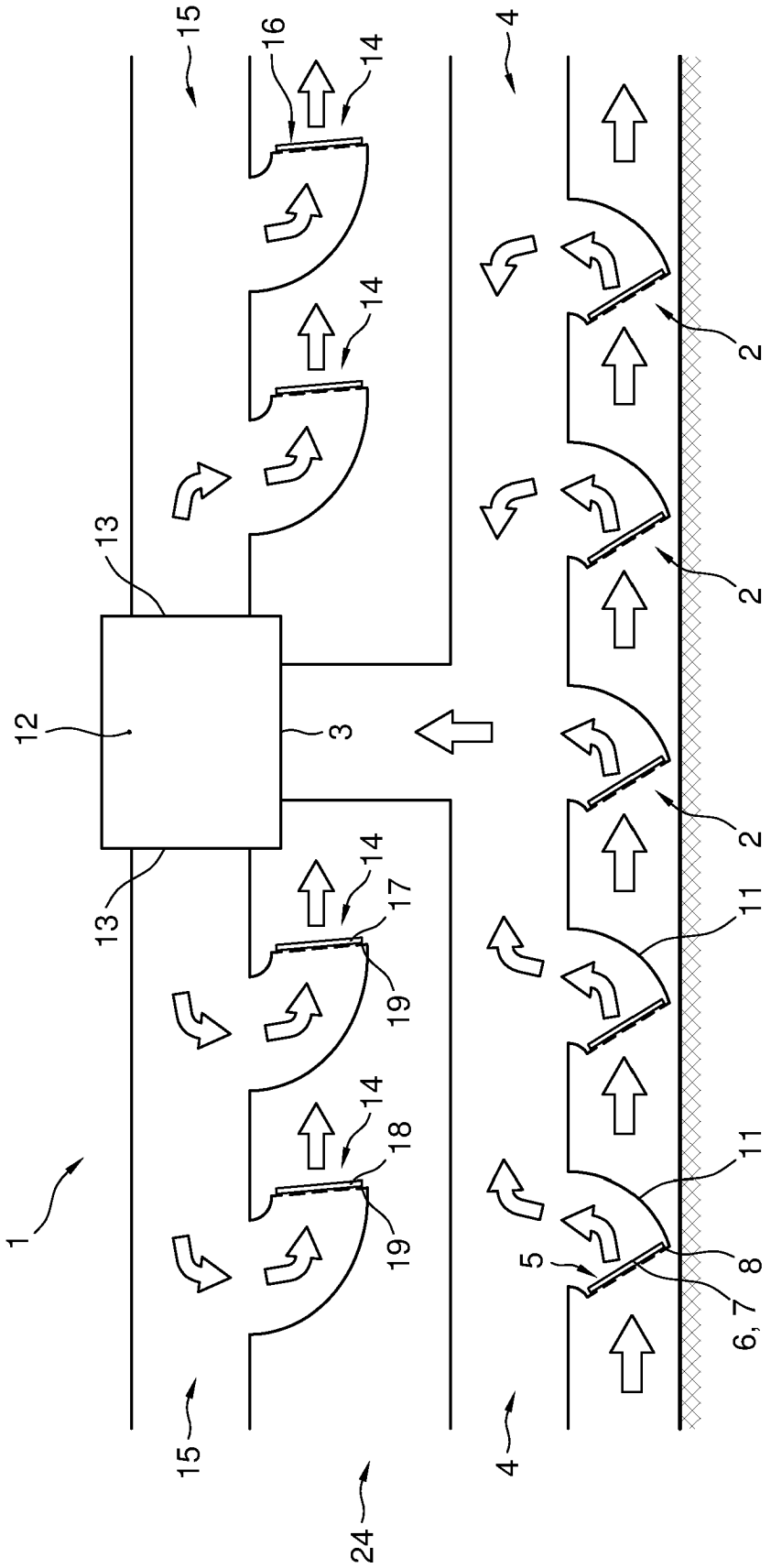


FIG. 3



II open position

FIG. 4



I closed position

FIG. 5

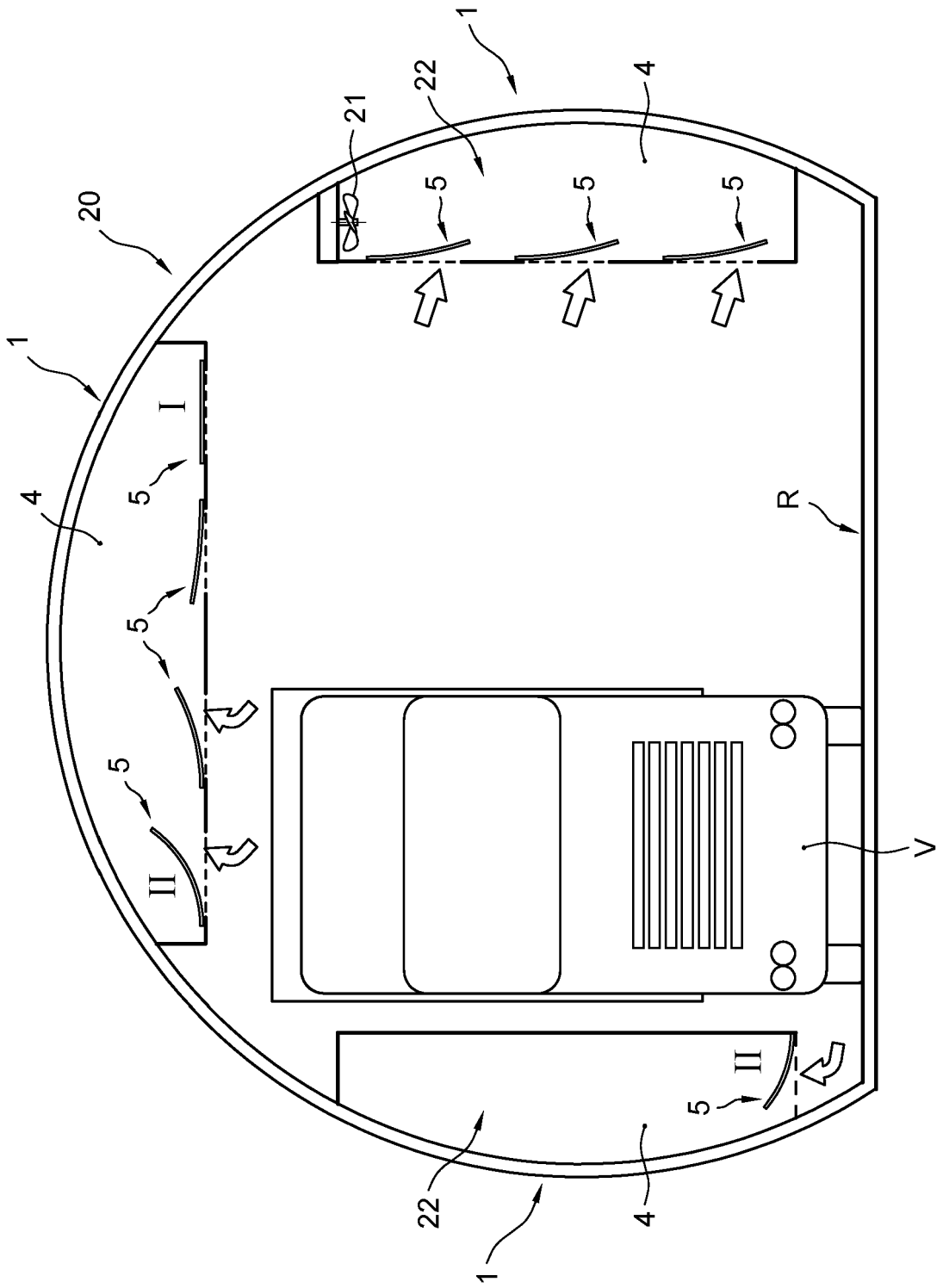


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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