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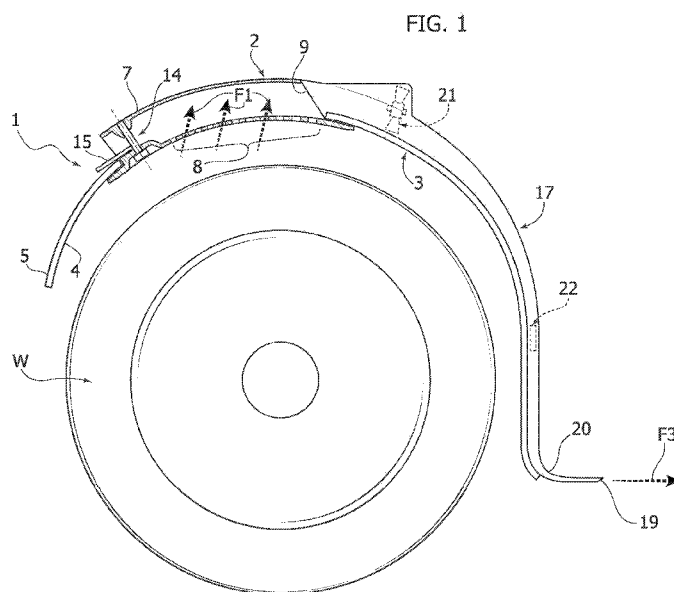
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(54) Title: A CARBON DIOXIDE CAPTURE SYSTEM FOR MOTOR-VEHICLE



(57) Abstract: A carbon dioxide adsorber system (1) for motor-vehicles, arranged to remove carbon dioxide from the atmosphere, when the vehicle is moving. The system (1) comprises a carbon dioxide capture module (2) mounted on a wheel arch (3) of the vehicle, wherein said capture module (2) comprises an adsorbent cartridge (6) made of adsorbent material suitable for retaining carbon dioxide, and a hollow casing (7) containing said cartridge (6). The hollow casing (7) comprises at least one inlet opening (8) for entry of an airflow into the casing (7), to be treated with the cartridge (6), and at least one outlet opening (9) for releasing carbon dioxide-free air. The system (1) also comprises at least one active element (21) arranged to generate an airflow that passes through at least one portion of the cartridge (6), so as to guarantee adsorption of carbon dioxide even in the absence of natural aerodynamic effects generated along the wheel arch (3) with vehicle speeds above a certain value.

KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,
MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA,
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“A carbon dioxide capture system for motor-vehicles”

TEXT OF THE DESCRIPTION5 **Field of the invention**

The present invention concerns a carbon dioxide capture system for motor-vehicles. The invention finds particular, although not limiting, application in the field of electric propulsion motor-vehicles, with the object of proposing a motor-vehicle with negative carbon dioxide emissions.

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Prior art

Various solutions of the type indicated above have already been proposed in the past, in order to reduce the polluting emissions of a vehicle, in particular by means of carbon dioxide adsorber devices. For example,

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WO 2017 212 381 illustrates a vehicle air purifier system having a carbon dioxide capture device (also called a carbon dioxide scrubber) integrated into the vehicle exhaust system.

However, the solutions known to date are not fully satisfactory from several points of view, including the high complexity with consequent high development costs, as well as the need to implement the system on a vehicle with totally electric propulsion.

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Object of the invention

The object of the present invention is to overcome the drawbacks of the solutions known to date, proposing a system totally compatible with a purely electric propulsion vehicle.

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In particular, an object of the present invention is to propose a carbon dioxide capture system for motor-vehicles, which is extremely simple and economical to create.

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A further object of the present invention is to create a system of the type indicated above which reduces to a minimum the complexity of the maintenance operations to be carried out periodically on the system components.

A further object of the present invention is to create a system of the type indicated above which is effective even at low vehicle speeds and with

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the vehicle stationary.

Summary of the invention

5 According to one or more embodiments, one or more of the above-mentioned aims are achieved through a carbon dioxide adsorber system for motor-vehicles having the characteristics set forth in the attached claims.

In particular, the invention relates to a carbon dioxide adsorber system for motor-vehicles, arranged to remove carbon dioxide from the atmosphere, comprising:

- 10 - a vehicle wheel arch forming an arched-shaped body prevalently spaced around the rotation axis of the relative wheel,
- at least one carbon dioxide capture module mounted on said wheel arch,
- wherein said capture module comprises an adsorbent cartridge
- 15 made of adsorbent material suitable for retaining carbon dioxide, and a hollow casing containing said cartridge,
- wherein said hollow casing comprises at least one inlet opening for the entry of an airflow into the casing, to be treated with the cartridge, and at least one outlet opening for releasing carbon dioxide-free air,
- 20 - a duct extending along the wheel arch behind the module and in fluid communication with the outlet opening of the hollow casing, wherein said duct is configured to convey and discharge the carbon dioxide-free airflow coming from the casing, after direct exposure of the cartridge,
- at least one active element arranged to generate an airflow that
- 25 passes through at least one portion of the cartridge and flows along the duct up to an outlet so as to guarantee adsorption of carbon dioxide even in the absence of natural aerodynamic effects generated along the wheel arch with vehicle speeds above a certain value.

30 Further preferred characteristics of the invention are described in the attached claims and in the description that follows.

Brief description of the figures

35 Further characteristics and advantages of the invention will become apparent from the description that follows with reference to the attached

drawings, provided purely by way of non-limiting example, wherein:

- Figure 1 is a partially sectioned side view illustrating a preferred embodiment of a carbon dioxide capture system mounted on a wheel arch of the vehicle,

5 - Figure 2 is a partially exploded perspective view of the system illustrated in the previous figure,

- Figure 3 is a perspective view of a carbon dioxide capture module including an adsorbent cartridge,

10 - Figure 4 is a partially sectioned view of the module of the previous figure in the assembled configuration,

- Figure 5 is an enlarged scale view of additional characteristics of the system illustrated in Figures 1, 2.

Detailed description of more embodiments

15 In the following description various specific details are illustrated aimed at a thorough understanding of examples of one or more embodiments. The embodiments may be implemented without one or more of the specific details, or with other methods, components, materials, etc. In other cases, known structures, materials or operations are not shown or
20 described in detail to avoid obscuring various aspects of the embodiments. The reference to “an embodiment” in the context of this description indicates that a particular configuration, structure or characteristic described in relation to the embodiment is included in at least one embodiment. Therefore, phrases such as “in an embodiment”, possibly present in
25 different places of this description do not necessarily refer to the same embodiment. Moreover, particular conformations, structures or characteristics can be combined in a suitable manner in one or more embodiments and/or associated with the embodiments in a different way from that illustrated here, for example, a characteristic here exemplified in
30 relation to a figure may be applied to one or more embodiments exemplified in a different figure.

The references illustrated here are only for convenience and do not, therefore, delimit the field of protection or the scope of the embodiments.

35 In the attached drawings, reference 1 generally indicates a carbon dioxide capture system for motor-vehicles, capable of capturing carbon

dioxide from the atmosphere during use of the motor-vehicle, in an area close to the system 1.

According to the present invention, the capture system 1 comprises a carbon dioxide capture module 2 mounted on at least one of the wheel arches 3 of the vehicle, preferably on the wheel arches of the front wheels of the motor-vehicle. As is known, a wheel arch 3 is a component of the vehicle bodywork, generally arched in shape, which delimits a compartment in the bodywork, having the function of containing and covering one of the wheels W of the vehicle. Being positioned in the wheel arch 3, the carbon dioxide capture module 2 advantageously exploits the aerodynamic effects caused by the apparent airflow hitting the vehicle, as well as those caused by the swirling airflow generated by the rapid rotation of the wheel W. Therefore, the module 2 is mounted in an area of the vehicle wherein the air pressure is higher than the ambient atmospheric pressure. This positioning of the capture module 2 is also advantageous since it allows the entire layout of the components of the system 1 along the wheel arch 3 to be rationalized and optimized.

The wheel arch 3 may be made, for example, from a shaped body of sheet metal or plastic, which includes at least one band that develops mainly in an arc around the rotation axis of the relative wheel W, so as to present a concave intrados 4 configured to define a portion of the outer surface of the bodywork and facing radially towards the wheel W, and an opposite convex extrados 5 facing the inside of the bodywork.

With particular reference to Figure 3, the module 2 comprises an adsorbent cartridge 6 made of adsorbent material suitable for retaining carbon dioxide, and a hollow casing 7 containing said cartridge 6. The casing 7 and the cartridge 6 are also made with a generally arched shape for positioning along the wheel arch 3, where it has been found that an effective overpressure area is normally present.

With reference to the configuration assembled on the wheel arch, the casing 7 comprises a lower wall facing the wheel W of the vehicle, an upper wall opposite the lower wall, two opposite side walls extending substantially along the longitudinal direction of the vehicle, a substantially transverse front wall, which joins opposite side walls, and a rear wall opposite to the front wall. In the assembled configuration, the casing 7 is connected to the

wheel arch 3, and is arranged inside a compartment 10 obtained along the arched band forming the wheel arch 3, so that the lower wall of the casing 7 is aligned with the intrados 4 of the wheel arch 3 (Figure 2).

5 In accordance with the illustrated embodiment, the casing 7 and the cartridge 6 have a general trapezoidal prism shape, with main surfaces of an arch shape to follow the line of the wheel arch 3. Of course, the cartridge 6 is smaller in size than the casing 7 to allow its positioning inside the hollow casing. In a preferred embodiment, the compartment 10 to accommodate the module 2 is obtained along a front area of the wheel arch 3 (with
10 reference to the configuration mounted on the vehicle), substantially up to the upper point of the arch defined by the wheel arch 3. Beyond the upper point, the wheel arch 3 extends substantially up to the floor of the vehicle. In other embodiments, the compartment 10 for receiving the module 2 extends beyond the upper point of the wheel arch 3.

15 The outer casing 7 comprises at least one inlet opening 8 to allow the entry of an airflow within the casing 7, to be treated with the cartridge 6, and at least one outlet opening 9 to let the carbon dioxide-free air leave. Since the module 2 is installed in an overpressure area, when the vehicle is moving, the air is sucked into the casing 7, to be treated with the cartridge
20 6, which captures the carbon dioxide. Of course, the general configuration of the inlet and outlet openings 8,9, as well as the shape of the cartridge 5 are arranged to ensure that the incoming airflow, before leaving the hollow casing 7, hits the body of the cartridge 6, maximizing the effectiveness of the carbon dioxide capture action.

25 In a preferred embodiment, as illustrated in Figures 3, 4, the inlet opening 8 is made with a plurality of slits 11 placed side by side and spaced apart transversally along the aforesaid lower wall of the hollow casing 7.

Preferably, the slits 11 have a substantially straight conformation, elongated along the entire width of the casing 7, and a spacing spaced apart
30 at a constant pitch with respect to each other, along the lower wall of the casing 7. By means of this configuration, the overpressurized air is sucked into the casing 7 through the slits 11, as indicated in the arrows F1 of Figures 1, 4. The airflow then hits the body of the cartridge 6 placed inside the hollow casing 7, up to the outlet opening 9. As illustrated in particular in Figure 3,
35 the outlet opening 9 is formed along the rear wall of the hollow casing 7.

Therefore, with the vehicle in motion, the air enters the hollow casing 7 through the slits 11 arranged in the overpressure area. The carbon dioxide remains trapped inside the cartridge 6, and the air flows through the outlet opening 9.

5 Looking in particular at the exploded view of Figure 3, the cartridge 6 comprises an outer surface 12 of breathable and air-permeable material, inside of which there is a body of adsorber material 13 suitable for retaining carbon dioxide. Preferably the body of adsorbent material 13 is made of
10 grains of lithium hydroxide (LiOH) or soda lime, or other substances as long as they are suitable for the intended purpose.

 According to another characteristic of the invention, the module 2 containing the cartridge 6 is removably connected to the wheel arch 3 by means of fixing means 14 configured to be able to pick up the module 2 to proceed with the maintenance operations and/or replacement of the
15 cartridge.

 In fact, it should be noted that the adsorbent cartridge 6 is designed to dispose of a certain quantity of carbon dioxide up to a level of total saturation, beyond which it is no longer able to perform the adsorption function. Therefore, during the life of the vehicle, once saturation has been
20 reached, the cartridge 6 must be replaced with a new cartridge ready for use, or be regenerated using regeneration processes known in the technological sector in question, before being installed again on board the vehicle.

 In this regard, in one or more embodiments, the cartridge 6 may be
25 extracted from the outlet opening 9 or from an access door (not shown) obtained along the upper wall of the casing 7.

 Once the cartridge 6 has been replaced, when the module 2 has been placed inside the compartment 10, the fixing means 14 may be operated manually to fix the module 2 again to the wheel arch 3.

30 In one or more embodiments, the fixing means 14 comprise fixing members associated with a front part and a rear part of the casing 7, for mutual engagement with corresponding portions of the wheel arch 3, after having positioned the module 2 within the compartment 10. With reference to Figure 1, the front fixing member comprises an engagement fin 15
35 rotatably mounted on a front portion of the casing 7, between a protruding

position, configured for engaging with the wheel arch 3 in particular above the extrados 5 (Figure 1), and a rotated position configured for freeing the front portion of the casing 7 from the corresponding front portion of the wheel arch 3. With reference to Figure 3, the rear fixing member comprises a pair of engagement levers 16 arranged for mutual engagement with the extrados 5 of the wheel arch 3 at a rear portion of the compartment 10. In accordance with the illustrated embodiment, the pair of levers 16 is provided on opposite sides of the casing 7, at a rear area of the casing 7 wherein the aforesaid outlet opening 9 is provided. Of course, the fixing means 14 for removably engaging the module 2 to the wheel arch 3 may be made in different ways than those described and illustrated, as long as they are suitable to allow a reliable rigid connection on the wheel arch 3 and - at the same time - allow the removal of the module 2 to proceed with the replacement of the cartridge 6.

According to a further characteristic of the invention, the capture system 1 comprises an aerodynamic diffuser 17 fluidly in communication with the outlet opening 9 of the carbon dioxide capture module 2. The diffuser 17 forms a duct configured to convey and discharge into the environment the carbon dioxide-free airflow coming from the casing 7, after direct exposure of the cartridge 6.

As illustrated in the attached drawings, in particular in Figure 5, the diffuser 17 comprises an inlet mouth 18 and an outlet mouth 19, and is spaced along the wheel arch 3, in particular above the extrados 5, behind the module 2. In the assembled configuration, the outlet opening 9 of the module 2 and the inlet mouth 18 of the diffuser 17 are spaced apart consecutively along the wheel arch 3, substantially presenting the same dimensions. To minimize air leaks, a gasket is mounted along the edge defining the outlet opening 9, and is in contact with the front surface of the inlet mouth 18.

As indicated previously, the diffuser 17 is configured to convey and discharge the carbon dioxide-free airflow coming from the outlet opening 9 into the environment. More specifically, the diffuser 17 is designed to create a reduction in outlet pressure, thus increasing the pressure difference between the inlet and outlet in order to optimize the flow rate and efficiency of the system 1. The diffuser 17 extends above and along the extrados 5 of

the wheel arch 3, from the outlet opening 9 of the casing 7, up to the rear end of the wheel arch 3.

As illustrated in Figures 1, 2, 5, the end part of the diffuser 17 comprises an air-outlet 20 having the outlet mouth 19. Preferably, the diffuser 17 has a general substantially S-shaped conformation with the inlet mouth 19 close to the upper point of the wheel arch, and the air-outlet 20 extending horizontally beyond the wheel arch 3 and under the floor of the vehicle, optimizing the discharge of the carbon dioxide-free outlet flow. In this regard, note that the air-outlet 20 is a divergent mouth with respect to the width of the duct extended between the inlet mouth 18 and the outlet mouth 19.

According to an additional characteristic of the invention, the capture system 1 comprises at least one active element 21 configured to maintain a carbon dioxide capture effect, even below a certain vehicle speed, above which the airflow that enters the cartridge 6 through the slots 11 is reduced until it stops. The active element 21 is, therefore, arranged to generate an airflow that passes through at least one portion of the cartridge 6 and flows along the diffuser 17 up to the outlet mouth 9, even with low vehicle speed, and even with the vehicle practically stationary, for example, during parking maneuvers.

In one or more embodiments, as illustrated in Figures 1, 2, 5, said active element 21 is a fan that is integrated inside the duct extended between the inlet mouth 18 and the outlet mouth 19, axially arranged in a position proximal to the inlet mouth 18. The fan may, therefore, be controlled to generate an airflow, to ensure the carbon dioxide capture action even in the absence of the natural aerodynamic effects that are generated along the wheel arch.

Again with reference to Figures 1, 2, 5, the capture system 1 may comprise at least one sensor 22 associated with the active element 21, designed to detect the pressure and/or speed of the airflow flowing towards the outlet mouth 19. The sensor 22 may also be positioned inside the duct extended between the inlet mouth 18 and the outlet mouth 19, in a suitable area wherein a stable steady flow is generated, for example, in a position spaced apart from the active element 21, close to the outlet mouth 19.

In one or more embodiments, the sensor 22 is able to recognize if

the suction grille - formed with the slits 11 - is obstructed by any residues of mud or foreign bodies and/or if the cartridge 6 presents an internal resistance to the passage of air which is modified due to the physical/chemical transformations due to the capture of carbon dioxide, until
5 it is identified that the cartridge 6 is saturated and requires replacement/regeneration.

Note that the active element 21 and the sensor 22 may be positioned in a protected area along the duct, in the most appropriate area both from the point of view of the spaces available in the car and to guarantee
10 operating performance.

In one or more embodiments, the active element 21 and the sensor 22 are controlled according to a control logic implemented by a vehicle control unit or on a dedicated electronic board integrated into the system 1, so as to facilitate the capture of carbon dioxide even at low speed and when
15 the vehicle is stationary, for example, while charging. In one or more embodiments, the active element 21 may be suitably adjusted with different operating speeds, for example, as a function of the vehicle speed.

In one or more embodiments, the active element 21 is activated when at least one of the following conditions occurs:

- 20 - vehicle speed below a limit value, below which a natural aerodynamic effect necessary for the capture of carbon dioxide is not guaranteed;
- critical conditions of turbulence inside the wheel arch that do not guarantee a natural airflow;
- 25 - blocked grille conditions also providing the relevant feedback to the driver;
- charging step of the electric car.

During operation, regardless of the presence of the active element 21, in the overpressure area that is generated during the movement of the vehicle, the air enters the cartridge 6 through the slits 11 of the casing 7
30 (arrows F1 in Figures 1, 4). The airflow passes through the cartridge 6 (arrows F2 in Figure 4) and leaves through the diffuser 17 in an area with lower pressure than that in the inlet area (arrows F3 in Figures 1, 5).

Preferably, by creating the diffuser 17 along the wheel arch 3, it is
35 also advantageously possible to create a single structural component of the

vehicle that incorporates the wheel arch 3 and the aerodynamic diffuser 17 in fluid communication with the outlet opening 9 of the module 2.

Thanks to the implementation of at least one active element 21 as described above, the system 1 is also configured for:

- 5 - capturing carbon dioxide even at low speed or with the vehicle almost stationary, for example, during parking operations or in underground parking areas where the air may be overloaded with carbon dioxide;
- capturing carbon dioxide when the vehicle is charging electrically, particularly inside a public or private garage;
- 10 - facilitating the capture of carbon dioxide in the event of obstruction of the intake grille or increase in internal resistance of the cartridge itself due to the physical/chemical transformation of the carbon dioxide capture substances.

Note that the present invention achieves further advantageous effects, even when the cartridge 6 is now saturated and is no longer able to dispose of quantities of carbon dioxide present in the air entering the casing 7, in particular:

- sound-absorbing effect of airborne noise generated in the wheel compartment, depending on the size of the module;
- 20 - improvement of the general aerodynamics of the wheel arch with reduction of aerodynamic resistance.

In one or more embodiments, the system 1 is implemented on all the wheel arches 3 of the vehicle,

In one or more embodiments, the system 1 also comprises sensor means (not shown) configured to warn the user, for example, by means of a warning light on the instrument panel of the vehicle, that the saturation level of the cartridge 6 has been reached. In this way, the user will be promptly notified that the cartridge 6 must be regenerated and, therefore, replaced.

30 In one or more embodiments, the system 1 also comprises additional sensor means suitable for warning the user of any mud residues or foreign bodies that close the inlet opening 9 of the module 2, so as to be able to proceed with washing the vehicle and/or freeing the inlet opening 9 to allow full functionality of the system 1.

35 Of course, without prejudice to the principle of the invention, the

details of construction and the embodiments may vary widely with respect to those described and illustrated purely by way of example, without departing from the scope of the present invention, as defined by the attached claims.

CLAIMS

1. A carbon dioxide adsorber system (1) for motor-vehicles, arranged to remove carbon dioxide from the atmosphere, comprising:

- 5 - a vehicle wheel arch (3) forming an arched-shaped body prevalently spaced around the rotation axis of the relative wheel (W),
 - at least one carbon dioxide capture module (2) mounted on said wheel arch (3),

 - wherein said capture module (2) comprises an adsorbent cartridge (6) made of adsorbent material suitable for retaining carbon dioxide, and a hollow casing (7) containing said cartridge (6),

 - wherein said hollow casing (7) comprises at least one inlet opening (8) for entry of an airflow into the casing (7), to be treated with the cartridge (6), and at least one outlet opening (9) for releasing carbon dioxide-free air,

15 - a duct extending along the wheel arch (3) behind the module (2) and in fluid communication with the outlet opening (9) of the hollow casing (7), wherein said duct is configured to convey and discharge the carbon dioxide-free airflow coming from the casing (7), after direct exposure of the cartridge (6),

20 - at least one active element (21) arranged to generate an airflow that passes through at least one portion of the cartridge (6) and flows along the duct up to an outlet (19), so as to guarantee adsorption of carbon dioxide even in the absence of natural aerodynamic effects generated along the wheel arch (3) with vehicle speeds above a certain value.

25 **2.** A system (1) according to claim 1, wherein said at least one active element (21) is a fan that is integrated inside the duct, axially arranged at a position proximal to an inlet mouth (18) of the duct.

3. A system (1) according to claim 2, comprising at least one sensor (22) associated with the active element (21), arranged to detect pressure and/or speed of the airflow flowing towards the outlet mouth (19).

30 **4.** A system (1) according to claim 3, comprising an electronic unit configured and programmed to control said active element (21) and said sensor (22) according to a control logic implemented so as to favor capture of carbon dioxide at low vehicle speeds and even when the vehicle is
35 stationary, for example, during a recharging phase.

5. A system (1) according to claim 1, wherein the casing (7) and the cartridge (6) are made with generally arched shapes for positioning along the wheel arch (3), at an effective overpressure zone of the vehicle, in the assembled configuration.

5 **6.** A system (1) according to claim 5, wherein the casing (7) is connected to the wheel arch (3) and is arranged within a compartment (10) formed along the arched shaped body forming the wheel arch (3), so that, in the assembled configuration, a lower wall of the casing (7) facing the wheel (W) is aligned with an intrados surface (4) of the wheel arch (3).

10 **7.** A system (1) according to claim 6, wherein the inlet opening (8) is made by a plurality of slits (11) placed side by side and spaced transversely along the lower wall of the hollow casing (7).

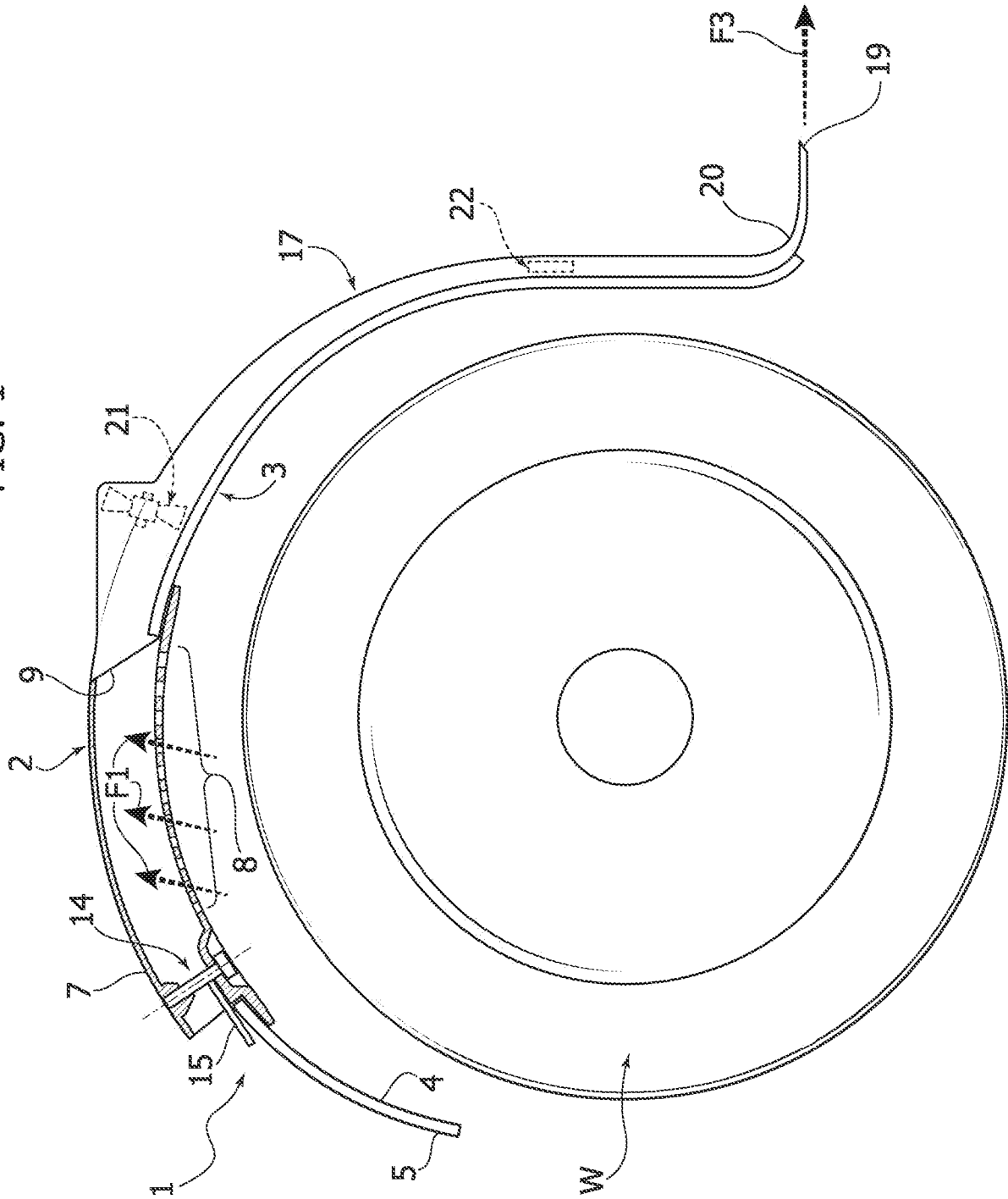
15 **8.** A system (1) according to any of the preceding claims, wherein the outlet opening (9) is formed along a rear wall of the hollow casing (7), to let the airflow treated by the cartridge (6) flow out.

9. A system (1) according to any of the previous claims, wherein the module (2) is removably connected to the wheel arch (3) by means of fixing means (14) configured to be able to pick up the module (2) and proceed with the replacement of the cartridge (6).

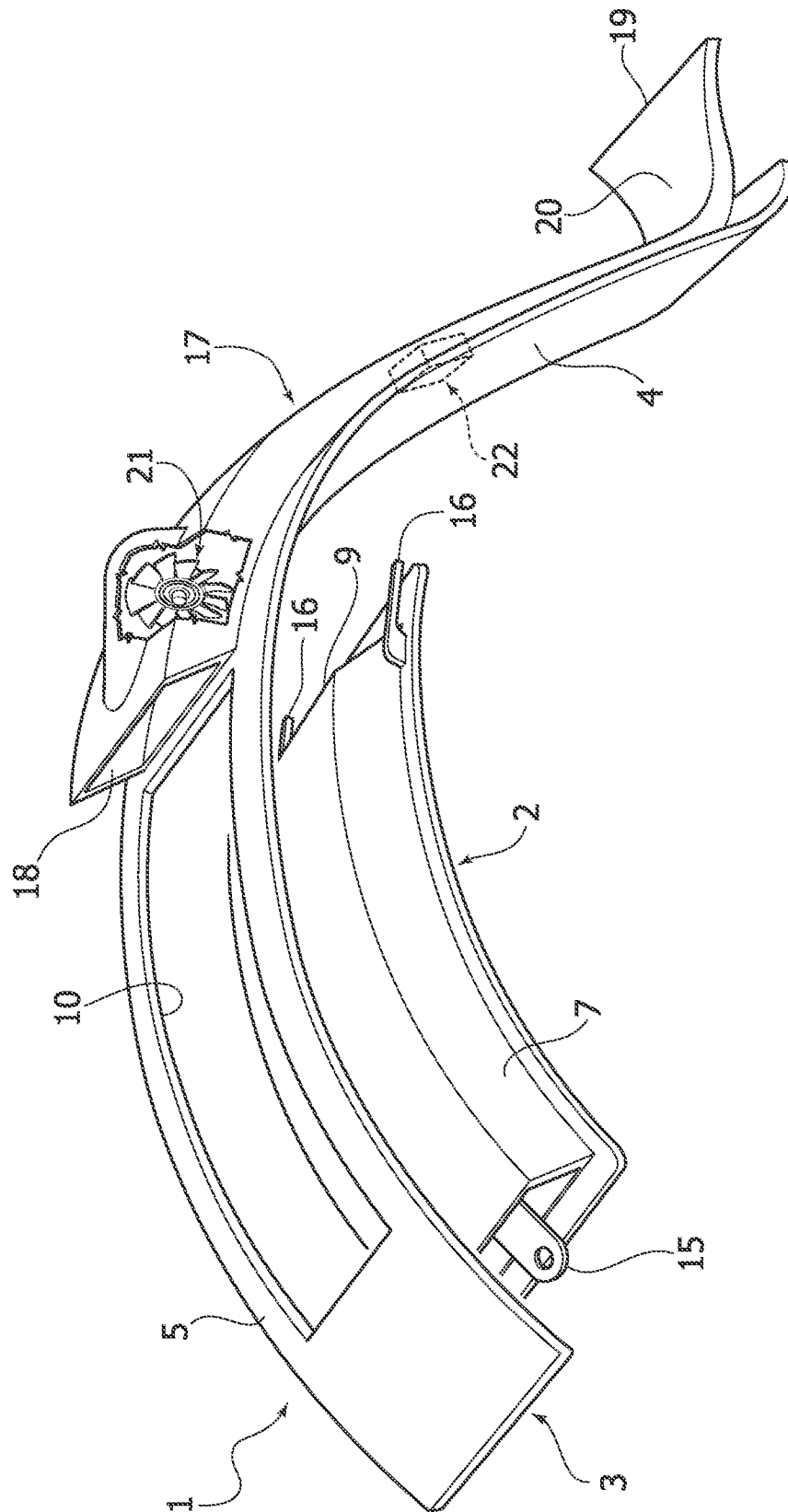
20 **10.** A system (1) according to any of the preceding claims, wherein said duct is configured as an aerodynamic diffuser (17) comprising an air-outlet (20) extending beyond the wheel arch (3) and under the vehicle floor, in the assembled configuration.

25 **11.** A motor-vehicle comprising at least one system (1) according to any one of the preceding claims.

FIG. 1



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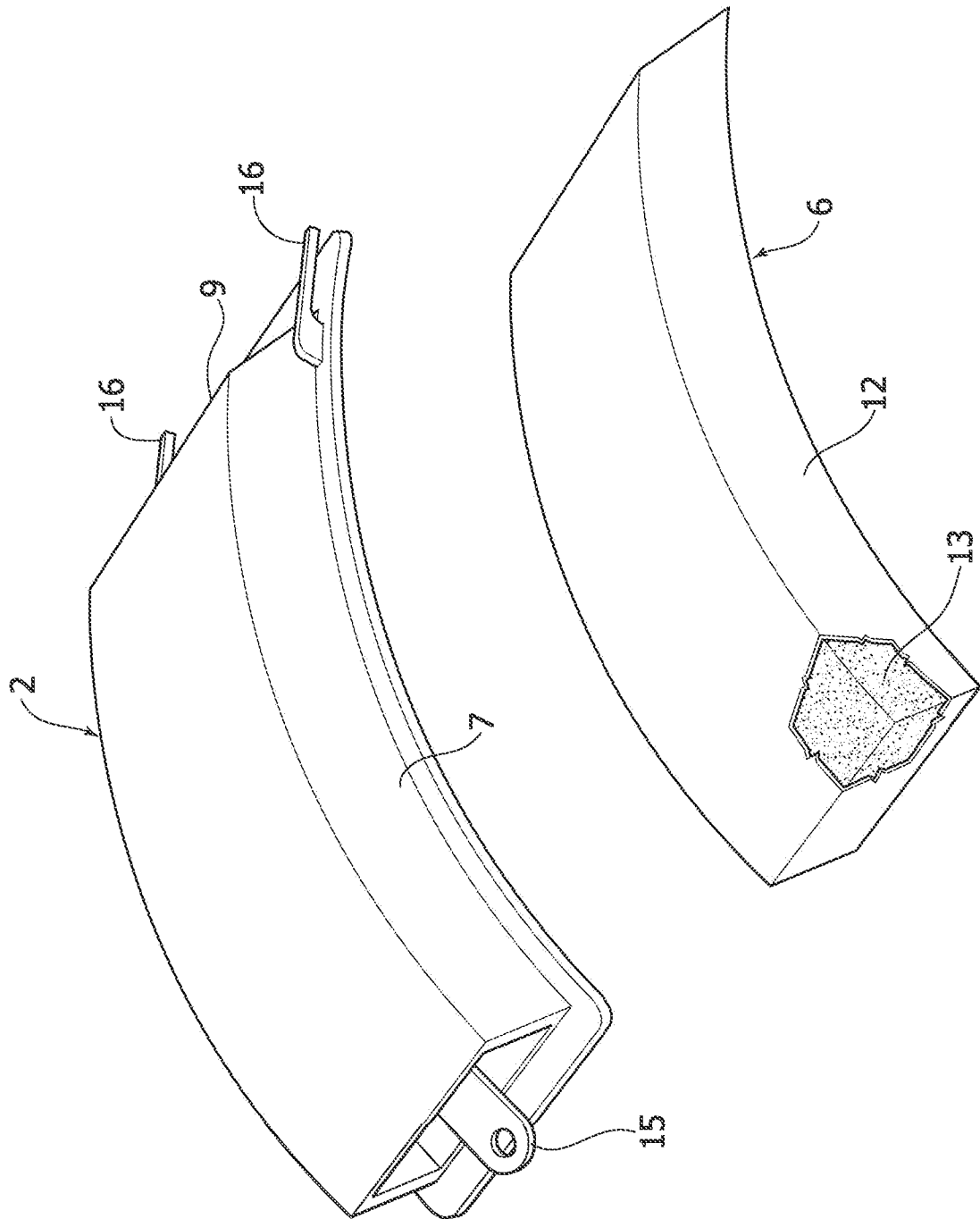


FIG. 4

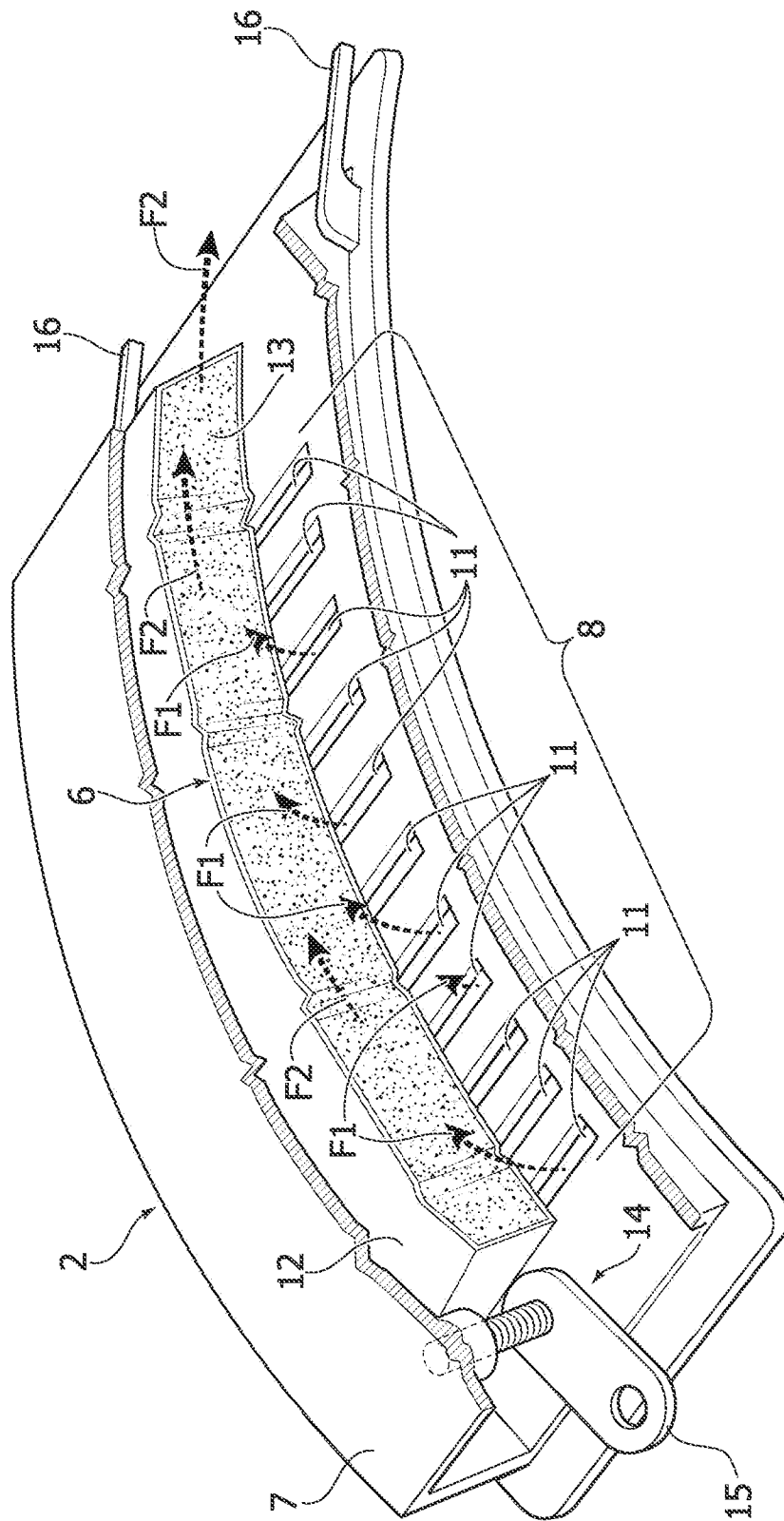
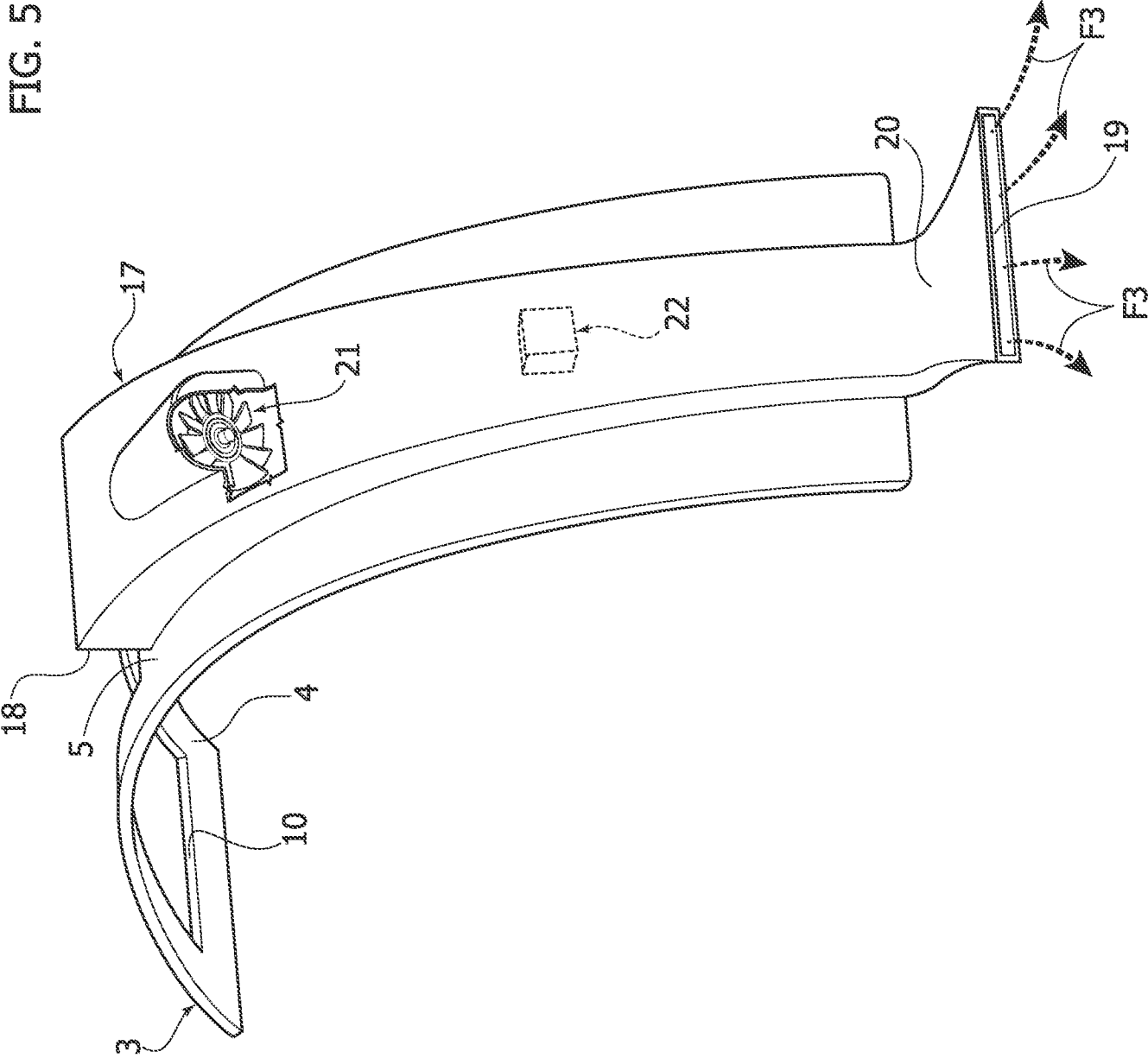


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/051653

A. CLASSIFICATION OF SUBJECT MATTER INV. B01D53/04 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) B01D F01N		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2022/184546 A1 (MILLER ERIC T [US]) 16 June 2022 (2022-06-16) figures 1,2,7,8,15,18 -----	1 - 11
A	US 2021/106941 A1 (AIBA TAKAO [JP] ET AL) 15 April 2021 (2021-04-15) figure 1 paragraphs [0053], [0065] -----	1 - 11
A	EP 3 805 532 A1 (TOYOTA MOTOR CO LTD [JP]) 14 April 2021 (2021-04-14) figure 4 paragraphs [0020], [0079], [0080] -----	1 - 11
A	WO 2004/080740 A1 (3K TECHNOLOGIES INC [US]; KRANTZ JEFFREY [US]) 23 September 2004 (2004-09-23) claims 1-3,6,14-17; figures 1,6-9 ----- - / - -	1 - 11
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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