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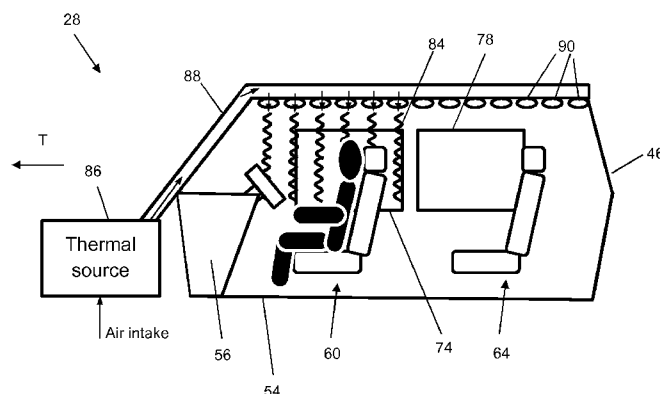


Fig. 5

(57) **Abstract:** Vehicle system for use in a vehicle, including a vehicle cabin defined, at least in part, by an upper cabin surface, a lower cabin surface and a side wall, the vehicle cabin having a seat (60) adjacent to the side wall, and an air flow system comprising at least one air vent (90) disposed in at least one of the upper cabin surface and the lower cabin surface, an airflow apparatus (28) configured to direct an airflow through the at least one air vent (90), wherein the at least one air vent (90) is configured to generate an airflow across the side wall so as to generate a thermal curtain (84) across the side wall, and a control system comprising one or more controllers configured to receive a seat signal relating to whether or not the vehicle seat (60) is occupied, generate a control signal to control the airflow through the at least one air vent (90) in dependence on the seat signal, and output the control signal so as to generate the thermal curtain (84) across the side wall if the seat (60) adjacent to the side wall is occupied.



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VEHICLE SYSTEM

TECHNICAL FIELD

The present disclosure relates to vehicle air flow systems. Aspects of the invention
5 relate to a vehicle system comprising a vehicle cabin and an air flow system, to a control system, to a method, to computer software, to a computer readable medium, and to a vehicle.

BACKGROUND

10 Conventional air conditioning systems dispense thermally conditioned air across the cabin space, thermally conditioning large areas of the vehicle. The thermally conditioned air is used to achieve a particular target temperature within the cabin space. The target temperature is typically higher or lower than the temperature of the environment exterior to the vehicle cabin space.

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Thermal transfer, also known as heat transfer, occurs between the cabin space and the exterior environment when the cabin space and exterior environment have different temperatures. Where thermal transfer is high, air conditioning systems consume large quantities of energy to achieve the target temperature. This is an issue in battery
20 electric vehicles (BEV), because consuming large quantities of energy significantly impacts the distance that a BEV can travel on a single charge.

It is an aim of the present invention to address one or more of the disadvantages associated with the prior art.

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SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a vehicle system provided with a vehicle cabin, an air flow system and a seat, a control system for an air flow system, a method, computer software, a computer readable medium, and a vehicle comprising
30 the vehicle system and/or the control system as claimed in the appended claims.

According to an aspect of the invention, there is provided a vehicle system for use in a vehicle, the vehicle system including a vehicle cabin defined, at least in part, by an upper cabin surface, a lower cabin surface and a side wall. The vehicle cabin has a

seat adjacent to the side wall and an air flow system comprising; at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface; an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to generate a thermal curtain across the side wall; and a control system, comprising one or more controllers, configured to: receive a seat signal relating to whether or not the vehicle seat is occupied, generate a control signal to control the airflow through the at least one air vent in dependence on the seat signal, and output the control signal so as to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.

The system, cabin and, air flow system provided by this aspect of the invention advantageously diminishes the effects or the perceived effects of heat transfer across a side wall of the cabin. The environment within the interior of the cabin within the region of a user can therefore be maintained at comfortable conditions efficiently.

In an example, the thermal curtain may act as a thermal barrier that reduces energy consumption by substantially inhibiting heat transfer by convection between different regions of the vehicle. In particular, the thermal curtain may substantially inhibit heat transfer by convection between regions of the cabin that are inboard and outboard of the thermal curtain. For example, the thermal curtain may provide a substantially laminar air flow between the vehicle seat and the sidewall. The laminar air flow may resist convection across it. In this manner, the cabin air inboard of the thermal curtain, for example in the region of the user, may be isolated from the cabin air outboard of the thermal curtain. The different regions of the vehicle can be maintained at different temperatures without mixing and, advantageously, heat transfer across the sidewall by conduction can be minimised by creating the isolated cabin regions. For example, the temperature of the cabin air outboard of the thermal curtain may be closer to the external temperature than the temperature of the cabin air inboard of the thermal curtain. As a result, the air flow apparatus does not have to expend excess amounts of energy to continually thermally condition the cabin against the effects of conduction through the side walls.

In another example, the perceived effects of heat transfer across the side wall of the cabin may be diminished by generating a thermal curtain that acts to control a surface temperature of the side wall. In this manner, the thermal curtain may heat an inner surface of the sidewall such that the surface is not cold to the touch or the thermal
5 curtain may cool the inner surface of the sidewall such that it does not feel too hot to a user.

The term adjacent may encompass being alongside, proximal to, in the region of, and/or surrounding a seat. In some examples, the thermal curtain is generated to
10 cover a part of the side wall aligned with the seat.

The air vent may be mounted to the upper cabin surface or the lower cabin surface. The air vent may be integrally formed with the upper cabin surface or the lower cabin surface. The air vent may be bi-directional, so that it can act as an inlet or an outlet to
15 the vehicle cabin.

The thermal curtain may be generated across the side wall to thereby minimise heat transfer by conduction across the side wall. The thermal curtain may be generated across the side wall to thereby control a surface temperature of the side wall; or to
20 thereby minimise a temperature difference between an interior surface of the side wall and the air within the vehicle cabin.

The vehicle system may be used in manual, semi-autonomous, or autonomous vehicles, and is particularly suited to road vehicles.

25

The vehicle cabin may have a seat that is moveable into a plurality of positions, in which case the one or more controllers may be configured to receive a seat signal relating to at least one of: whether or not the seat is occupied, and the position of the seat. In such embodiments, the one or more controllers may be configured to generate
30 a control signal to control the airflow apparatus in response to the seat signal. The seat may be moveable to each of the plurality of positions by any one or more of: longitudinal movement; lateral movement; rotational movement; reclining movement; and folding movement. The control signal may be configured to adjust automatically a status of one or more of the air vents in response to the seat signal.

The longitudinal movement, lateral movement, rotational movement, reclining movement, and/or vertical movement may be with respect to the vehicle cabin. The rotational movement may be rotational movement with respect to a vertical axis of the seat. The reclining movement may be reclining movement with respect to a horizontal axis of the seat.

The seat signal indicative of the position of the seat may include information relating to at least one of the location of the seat, orientation of the seat, the angle of recline of the seat, the height of the seat relative to a lower surface of the vehicle cabin, a folded status of the seat, and a head rest position of the seat.

Beneficially, the ability of the vehicle system to adapt its operation based on position as well as occupation leads to improvements in how effective the air flow system is at directing air over users, while reducing energy wastage by avoiding conditioning air in unoccupied areas of the cabin.

The one or more controllers are optionally configured to receive a temperature demand signal and to generate a control signal to control the airflow apparatus in response to the temperature demand signal. For example the one or more controllers may be configured to: receive a temperature demand signal and a temperature signal; compare the temperature demand signal and the temperature signal; and generate a control signal to control the airflow apparatus based on the comparison between the temperature demand signal and the temperature signal. The temperature demand signal may be indicative of the cabin air temperature.

The at least one air vent may be configured to direct the airflow in a substantially vertical direction across the side wall. Alternatively, the at least one air vent may be configured to direct the airflow in a substantially horizontal direction across the side wall.

The vehicle system may comprise a first airflow apparatus configured to direct a first airflow through at least one first air vent provided in one of the upper cabin surface or the lower cabin surface. The vehicle system may comprise a second air flow apparatus

configured to direct a second airflow through at least one second air vent provided in the other of the upper cabin surface or the lower cabin surface. The first and second air vents may be configured to direct airflows towards one another across said side wall. The airflows may be opposed to one another.

5

The first airflow apparatus may be configured to direct an air flow at a lower temperature than an air flow directed by the second air flow apparatus. Such a configuration has the advantage that the effect of natural convention, which causes warmer air lower in the vehicle to rise, is compensated or 'replenished' by the airflow directed from the second air flow apparatus.

10

Alternatively, the first airflow apparatus may be configured to direct an airflow at a greater temperature than an airflow directed by the second airflow apparatus.

It is particularly advantageous to direct an airflow at a higher temperature from at least one lower air vent provided in the lower cabin surface, and to direct airflow at a lower temperature from at least one upper air vent. The hotter airflow through the lower air vent tends to replenish the effects of natural convention which causes hot air at the lower surface to rise in the vehicle cabin towards the upper surface.

20

The vehicle system may comprise a first airflow apparatus configured to direct a first airflow to at least one upper air vent in the upper cabin surface. The vehicle system may comprise a second air flow apparatus configured to provide suction that draws the first airflow across said side wall into at least one lower air vent in the lower cabin surface.

25

The vehicle system may comprise a first airflow apparatus configured to direct a first airflow to at least one lower air vent in the lower cabin surface. The vehicle system may comprise a second air flow apparatus configured to provide suction that draws the first airflow across said side wall into at least one upper air vent in the upper cabin surface.

30

The first airflow apparatus may be configured to reduce the temperature of the side wall. The second airflow apparatus may be configured to increase the temperature of the side wall.

- 5 The first and/or second air flow apparatus may switch operation from directing air through the vents to providing suction that draws air flow through the vents. The first and/or second air flow apparatus may switch operation from providing suction that draws air flow through the vents to directing air through the vents.
- 10 The at least one upper air vent and the at least one lower air vent may be in vertical alignment with one another.

- Disposing air vents in an upper and/or lower surface of the cabin results in an improvement in the ability of the air flow system to provide a targeted air flow for
- 15 creating a thermal curtain. The combined effect of air vents in the upper and/or lower cabin surface and basing the control signal on occupation of seats permits air flow to be focussed towards a particular side wall within the vehicle cabin, resulting in improved efficiency and reducing losses. The variability in whether vents operate to provide suction or to direct air flow provides a highly customisable system that can
- 20 adequately adapt to different operational conditions and to implement a thermal curtain swiftly and effectively.

- According to an aspect of the invention there is provided a control system for controlling an air flow system of a vehicle, the vehicle having a vehicle cabin defined,
- 25 at least in part, by an upper cabin surface, a lower cabin surface and a side wall, the vehicle having: a seat adjacent to the side wall; at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface; and an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to
- 30 generate a thermal curtain across the side wall; the control system comprising one or more controllers, configured to: receive a seat signal relating to whether or not the vehicle seat is occupied; generate a control signal to control the airflow through the at least one air vent in dependence on the seat signal; and output the control signal so as

to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.

5 Optionally, the one or more controllers collectively may comprise: at least one electronic processor having one or more electrical inputs for receiving the seat signal; and at least one electronic memory device operatively coupled to the at least one electronic processor and having instructions stored therein; wherein the at least one electronic processor is configured to access the at least one memory device and execute the instructions stored therein so as to generate the control signal.

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Any controller or controllers described herein may suitably comprise a control unit or computational device having one or more electronic processors. Thus the system may comprise a single control unit or electronic controller or alternatively different functions of the controller may be embodied in, or hosted in, different control units or controllers.

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As used herein the term “controller” or “control unit” will be understood to include both a single control unit or controller and a plurality of control units or controllers collectively operating to provide any stated control functionality. To configure a controller, a suitable set of instructions may be provided which, when executed, cause
20 said control unit or computational device to implement the control techniques specified herein. The set of instructions may suitably be embedded in said one or more electronic processors. Alternatively, the set of instructions may be provided as software saved on one or more memory associated with said controller to be executed on said computational device. A first controller may be implemented in software run on
25 one or more processors. One or more other controllers may be implemented in software run on one or more processors, optionally the same one or more processors as the first controller. Other suitable arrangements may also be used.

30 The one or more controllers may be configured to receive a temperature signal indicative of an air cabin temperature, and output the control signal in dependence on the temperature signal. The one or more controllers may be configured to receive a user preference signal indicative of an air cabin temperature, and output the control signal in dependence on the user preference signal. The one or more controllers may

be configured to receive a seat signal indicative of the position of the seat, and output the control signal in dependence on the seat signal.

According to an aspect of the invention, there is provided a vehicle comprising the
5 vehicle system as described above or the controller as described above.

The side wall may be a vehicle door. The side wall may include a vehicle door. The vehicle door may include a glass window or daylight opening across which the thermal curtain is generated. The at least one upper air vent may be disposed in a member of
10 the vehicle chassis or body. For example, the at least one upper air vent may be disposed in a cant rail of the vehicle.

According to another aspect of the invention there is provided a method of controlling an air flow system for a vehicle having a vehicle cabin defined, at least in part, by an
15 upper cabin surface, a lower cabin surface and a side wall, the vehicle cabin having: a seat adjacent to the side wall; at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface; and an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to generate a thermal
20 curtain across the side wall; the method comprising: receiving a seat signal relating to whether or not the vehicle seat is occupied; generating a control signal to control the airflow through the at least one air vent in dependence on the seat signal, and outputting the control signal so as to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.

25

The method may comprise receiving a temperature signal and a temperature demand signal, and directing an airflow through at least one air vent in the upper cabin surface into the cabin if the temperature signal exceeds the temperature demand signal, and directing an airflow through at least one air vent in the lower cabin surface into the
30 cabin if the temperature demand signal exceeds the temperature signal. Such methods may also comprise directing an airflow out of the cabin through the at least one upper air vent if the temperature demand signal exceeds the temperature signal, and directing an airflow out of the cabin through the at least one lower air vent if the temperature signal exceeds the temperature demand signal.

According to an aspect of the invention there is provided computer software which, when executed by one or more processors, causes performance of a method according to a preceding aspect of the invention.

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According to an aspect of the invention there is provided a computer readable medium having instructions stored therein which, when executed by one or more processors, causes performance on a method according to a preceding aspect of the invention. Optionally, the computer readable medium comprises a non-transitory computer readable medium.

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Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

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BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

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Figure 1 shows a side view of a vehicle in accordance with an embodiment of the invention;

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Figure 2 shows a schematic diagram of an air flow system for controlling air flow within a vehicle cabin;

Figure 3 shows a schematic plan view of a vehicle cabin incorporating the air flow system of Figure 2;

Figure 4 shows a schematic cross-section of a vehicle cabin incorporating the air flow system of Figure 2;

5 **Figure 5** shows a schematic side view of a vehicle cabin incorporating the air flow system of Figure 2;

Figure 6 shows a schematic plan view of a vehicle cabin incorporating the air flow system of Figure 2; and

10

Figure 7 shows a method of operation of the air flow system of Figure 2.

DETAILED DESCRIPTION

15 Figure 1 shows a side view of a vehicle 10. The vehicle 10 has a vehicle body 12 supported on a plurality of wheels 14. In use, rotation of the wheels 14 by a motive source such as an engine causes the vehicle 10 to move, mainly in the forward direction of travel, indicated in Figure 1 by the arrow T. Of course, it will be appreciated that the vehicle 10 can also be caused to move in the opposite direction to the arrow T,
20 when in a reverse gear.

References in the following description to left and right, front, rear, forward, or backward, are made with reference to the direction T. References to upper, lower, horizontal, and vertical are made relative to the conventional orientation of the vehicle,
25 as shown in Figure 1. A lower surface is closer to the ground than an upper surface when the vehicle is supported by the wheels. The ground 16 may be used as a reference point as shown in Figure 1.

The vehicle 10 is provided with a vehicle system and comprises a vehicle body 12
30 which encloses a vehicle cabin. To reduce thermal transfer between an exterior of the vehicle and the vehicle cabin, or at the very least reduce the effect or perceived effect of thermal transfer, the vehicle 10 incorporates an air flow system 20. The airflow system 20 is represented by dashed lines in Figure 1, which is purely illustrative of the

presence of the system 20 in the vehicle 10 and is not intended to indicate any qualities of the system 20, which is described in more detail later.

5 The air flow system 20, which selectively controls air flow within the vehicle cabin, is shown in more detail in Figure 2. The air flow system 20 comprises a sensing system 22, a control system comprising a controller 24, a user preference module 26, and air flow apparatus 28. The controller 24 is a module within a body control module (BCM). The user preference module 26 may also be a module of the BCM or may be a module of an infotainment system.

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The air flow system 20 operates to reduce the effects of thermal transfer between the exterior environment and the interior of the vehicle cabin via conduction and/or convection. Particularly, the air flow system 20 operates to limit conduction of energy through low insulation regions in the vehicle cabin, such as windows, and convection
15 of energy through openings in the vehicle, such as openings surrounding doors and windows or apertures formed by an open window or door. Improvements in efficiency are achieved by limiting thermal transfer in volumes proximate to a user of the vehicle cabin, and specifically by forming a 'thermal curtain' across surfaces of the vehicle cabin close to the user. A thermal curtain is air flow that provides a barrier to
20 convection or conduction across the flow. The thermal curtain may be generated to control a surface temperature of the side wall so that it is warm to the touch and so that heat transfer is not detrimental to the interior conditions of the cabin. The thermal curtain may act to minimise a temperature difference between a surface of the side wall and the air in the exterior environment, again to minimise the effects of heat
25 transfer on the interior of the vehicle cabin. The perceived effects of heat transfer across the side wall of the cabin may be diminished by generating a thermal curtain that acts to control a surface temperature of the side wall. In this manner, the thermal curtain may heat an inner surface of the sidewall such that the surface is not cold to the touch or the thermal curtain may cool the inner surface of the sidewall such that it
30 does not feel too hot to a user.

The thermal curtain may also or alternatively substantially inhibit heat transfer by convection between regions of the cabin that are inboard and outboard of the thermal curtain. For example, the thermal curtain may provide a substantially laminar air flow

between a vehicle seat and a sidewall. The laminar air flow may resist convection across it. In this manner, the cabin air inboard of the thermal curtain, for example in the region of a user, may be isolated from the cabin air outboard of the thermal curtain. The different regions of the vehicle can be maintained at different temperatures without mixing and, advantageously, heat transfer across the sidewall by conduction can be minimised by creating the isolated cabin regions. For example, the temperature of the cabin air outboard of the thermal curtain may be closer to the external temperature than the temperature of the cabin air inboard of the thermal curtain. As a result, the air flow apparatus does not have to expend excess amounts of energy to continually thermally condition the cabin against the effects of conduction through the side walls.

To implement these solutions, the sensing system 22 provides inputs to the controller 24 indicating at least an occupancy status of seats within the vehicle cabin. The occupancy statuses of the seats are provided by occupancy sensors 30 associated with each of the seats. Occupancy sensors may be pressure sensors, imaging devices, seatbelt sensors, weight sensors, or any other suitable known system for determining whether or not a particular seat is occupied. The sensing system 22 comprises at least one temperature sensor 23 configured to provide to the controller 24 a temperature signal indicative of a temperature of the cabin.

20

The controller 24 also receives inputs indicating a measured temperature inside the vehicle cabin together with a temperature demand, namely a target temperature, typically specified by a user through an interface such as an infotainment system. The inputs indicating a measured temperature are received from the at least one temperature sensor 23.

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Although in this embodiment all required functions are provided by an integrated controller, in other embodiments the control system may comprise multiple controllers and/or control modules to implement the required functionality.

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In practice, each seat is provided with its own occupancy sensors 30 so that a plurality of occupancy signals are provided to the input 24a of the controller 24. It will be appreciated that a single occupancy sensor may also perform the same function. The sensing system 22 also comprises optional position sensors 32 that provide an input to

the controller 24 indicating a position of each seat within the vehicle cabin. The position of a seat is defined by its configuration, orientation/rotation, and/or location. Various seat position and/or occupancy sensors as known in the art may be used. The position sensors 32 therefore comprise configuration sensors 34 configured to monitor
5 a configuration of the seats, orientation sensors 36 configured to monitor an orientation of the seats, and/or location sensors 38 configured to monitor a location of the seats. Other position-related parameters may also be measurable by further sensors of the arrangement 32.

10 Orientation/rotation and location of a seat should be understood to have their conventional meanings. In manual vehicles, rotation of seats is highly limited, while the location of a seat is restricted to forward and backward movement along short rails. However, as will be described later in relation to Figure 6, seating configurations in autonomous or semi-autonomous vehicles may be highly variable.

15

The term 'configuration' is intended to encompass at least one of: a folded status of the seat; an angle of recline of the seat; a height of the seat relative to the lower surface 60 of the cabin 50; a head rest position of the seat; and, if included, a position of a foot rest and/or an arm rest. Other measurable parameters that do not fall under
20 rotation/orientation or location of the seat may also be considered to fall within the term 'configuration'. The folded status of the seat indicates whether the seat is in a folded position. The angle of recline of the seat is typically the angle at which the back 73 of the seat is reclined. The head rest position of the seat includes an angle of the headrest 74 and/or a height of the headrest 74 relative to the back 73.

25

The controller 24 or control system, utilising the occupancy status at least, determines how the air flow apparatus 28 should operate to reduce thermal transfer in the vicinity of any users. The controller 24 may also use the received input from position sensors, and/or any other received input such as the input received from the user preference
30 module 26. The user preference module 26 indicates any specific settings that the user wishes to implement in the control of the air flow system 20. The controller 24 generates a control signal 25 for controlling the air flow apparatus 28 based on its received inputs. The processor 24c may be configured to generate the control signal

by accessing a database, accessing a look-up table, or using any other processes and/or algorithms that are deemed suitable.

5 The control signal 25 is output from the controller 24 and received at the air flow apparatus 28. The air flow apparatus 28 operates according to the control signal 25 to implement the desired air flow within the vehicle cabin.

10 Although not depicted in Figure 2, the air flow apparatus 28 comprises a pump, a thermal source, air ducts, and air vents. In some examples, there may be more than one thermal source. The thermal source may include a heat exchanger that exchanges heat with other vehicle components such as a vehicle battery, a vehicle engine, or a coolant system. In use, the pump may draw air into the apparatus. The thermal source thermally conditions the air drawn in by the pump. The air is pumped from the thermal source through air ducts in the vehicle to the air vents, which consequently act as air
15 outlets. The air vents are positioned at a surface of the cabin to allow air flow from the apparatus to the interior 42 of the cabin 40. The air vents may be positioned in any surface of the vehicle cabin 40.

20 The air flow apparatus is configured to form one or more thermal curtains across walls of the vehicle cabin 40 using air vents positioned adjacent an edge of the walls. The air vents may alternatively be positioned along the wall, or may border the wall. By forming a thermal curtain, the volume within which the user is seated may be thermally protected from the side wall of the vehicle cabin adjacent the user by virtue of the thermal curtain. To form a thermal curtain across a side wall, for example, air flow is
25 directed through air vents adjacent the side wall and positioned in the upper surface and/or lower surface of the cabin so that air flow is directed in a substantially vertical direction to form a laminar flow across the side wall.

30 Alternatively, a thermal curtain may also be formed using air vents that direct air substantially horizontally. For example, air vents in a pillar of the vehicle cabin 40 can form a thermal curtain horizontally across a surface.

Air vents may be provided in the roof and/or floor of the vehicle cabin. The air vents may be mounted in the roof and/or floor, and in some examples, may be integrally

formed within the roof and/or floor. Air vents in the roof may be incorporated into the cant rail of the vehicle. Air vents may be provided in both the upper and lower surfaces. Air having different temperatures may be directed through air vents in different surfaces, either using a single apparatus or more than one apparatus. In some examples, the temperature of the air flowing through vents in the upper and lower surfaces may be designed to oppose natural convection. In some examples, air vents may operate as inlets, and air outlets in a surface may have corresponding opposed inlets in an opposite surface, so that air is drawn, actively or passively, from the outlets to the inlets to enhance the formation of a thermal curtain.

10

Thermal curtains formed over side walls may be used as a barrier to conduction, substantially reducing heat transfer through the walls between the interior volume of the cabin and the exterior environment. Thermal curtains may alternatively or additionally be formed as barriers to convection between volumes that are inboard and outboard of the thermal curtain or interior and exterior volumes of the cabin. In an example, the thermal curtains may alternatively or additionally control a surface temperature of the sidewall. The thermal curtains may provide a substantially laminar air flow between a vehicle seat and a side wall. The laminar air flow may resist convection across it. The thermal curtain may heat an inner surface of the sidewall such that the surface is not cold to the touch or the thermal curtain may cool the inner surface of the sidewall such that it does not feel too hot to a user.

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The air flow apparatus also incorporates at least one mechanism for regulating and selectively controlling the flow of air through the vents. The flow of air through the air vents may be controllable by control of valves disposed at the vents, by control of valves positioned in the ducts, or by a combination of valves at the vents and within the ducts. For example, a valve may be provided at each vent to prevent or partially prevent air flow. The valve may be manually or automatically controllable. Valve systems may also be incorporated to control air flow to subsets of air vents, so that air flow can be controlled for particular zones within the vehicle cabin. The air flow system and apparatus may be part of, or in addition to, an air conditioning system configured to thermally condition the cabin space. The air conditioning system may be configured to control the cabin temperature.

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To demonstrate the operation of the air flow system 20, an example vehicle cabin 40 including the air flow system 20 is shown in Figures 3 to 5. Figures 3 to 5 show respective plan, front, and side views of the vehicle cabin 40. The air flow apparatus 28 forming part of the air flow system 20 is partially depicted in Figure 5.

5

The cabin 40 comprises an enclosed interior volume 42 of the vehicle 10, is defined by the vehicle body 12. Taking T as a reference direction, the cabin 40 is surrounded and defined by respective interior surfaces of front and rear walls 44, 46, left and right side walls 48, 50, a roof 52, and a floor 54 of the vehicle body 12. As shown in Figure 2, the front and rear walls 44, 46 are substantially perpendicular to direction T. The left and right side walls 48, 50 are substantially parallel to direction T. The roof 52 extends between the upper edges of the walls, above the interior volume 42 when the vehicle 10 is in the orientation of Figure 1, and defines an upper surface. The floor 54 extends between the lower edges of the walls, below the interior volume 42 when the vehicle 10 is in the orientation of Figure 1, and defines a lower surface.

Within the cabin 40, a dashboard 56 extends along and is positioned adjacent the front wall 44. The dashboard 56 includes a steering wheel 58 for manual operation of the vehicle by user. The dashboard 56 and steering wheel 58 are not shown in Figure 4 for clarity. The dashboard 56 may additionally, or instead of the steering wheel, include displays, user input systems, speakers, other output systems and/or air vents. As will be well understood, dashboards and the features incorporated into dashboards are well known to the skilled person, and so they will not be elaborated on further.

While the vehicle depicted in each of these figures is a manual or semi-autonomous vehicle and so requires a steering wheel (or at least some form of user input to turn the vehicle), it will be appreciated that in fully autonomous vehicles a steering wheel may be omitted. In some autonomous vehicles, the dashboard may also be omitted entirely.

Disposed within the interior of the cabin 40 are four seats 60, 62, 64, 66. Using direction T as a reference, the four seats are: a front right seat 60; a front left seat 62; a rear right seat 64; and a rear left seat 66. The front left and rear left seats 62, 66 are not depicted in Figure 5 for clarity. Although Figures 3 to 5 are only schematic diagrams, it can be seen that each seat comprises a seat portion 68, a back 70, and a

headrest 72, as is conventional for vehicle seats. The seats 60, 62, 64, 66 are mounted within the cabin 40 by a mounting, which is not depicted in these schematics. Seats may also include a foot rest or one or more arm rests.

- 5 Windows 74, 76, 78, 80 are provided in the side walls 48, 50 alongside each seat 60, 62, 64, 66. The front right window 74 and rear right window 78 are positioned in the right side wall 48 adjacent the front right and rear right seats 60, 64 respectively. The front left window 76 and the rear left window 80 are positioned in the left side wall 50 adjacent the front left and rear left seats 62, 66 respectively.

10

Although not shown in the figures, the side walls also incorporate vehicle doors. The side wall may include a pair of doors, a single door, and/or any other door system as appropriate. The door itself may be transparent, translucent, or act as a daylight opening or region of low thermal insulation.

15

- In this example, the front right seat 60, the driver's seat, is occupied by a user 82. The controller 24 of the air flow system 20 will consequently receive an input signal from the occupancy sensors 30 to indicate that a user occupies this particular seat. The input signal received from the occupancy sensors 30 indicates that the front right seat
20 60 is occupied. Input signals are received from the occupancy sensors associated with the other seats to indicate that the other three seats 62, 64, 66 are not occupied.

- The controller 24 generates and dispatches a control signal 25 to the air flow apparatus 28 in response to the input signal(s) received from the occupancy sensor(s).
25 The control signal 25 controls the air flow apparatus 28 to generate a thermal curtain 84 across at least the side wall adjacent the seat the user is occupying. By generating a thermal curtain across the side wall, a barrier to conduction and/or convection is formed as described above. However, for efficiency, the control signal 25 is configured so that a thermal curtain is not caused to be formed adjacent to other seats of the
30 vehicle where no passengers occupy the seats. However, it will be appreciated that, in other examples, a thermal curtain may be generated in different areas of the cabin if other criteria are fulfilled. For example, unlocking a door of the vehicle may cause a thermal curtain to be generated to form a barrier to convection through the door.

The thermal curtain is formed by the air flow apparatus 28, and more particularly using thermally conditioned air directed to flow through air vents in the cabin across the side walls as described above.

- 5 This process is depicted in Figure 5, which depicts the thermal source 86, ducts 88, and air vents 90 of the air flow apparatus 28. Air is received at the thermal source 86 via the air intake 92. The thermal source 86 thermally conditions the air. The air from the thermal source 86 is communicated to the ducts 88. In Figure 5, the ducts 88 are depicted as being disposed along surfaces of the front wall 44 and roof 52, although it
10 will be appreciated that the ducts may be arranged to take any route to connect the thermal source and vents. For example, pillars in each of the front, rear, or side walls 44, 46, 48, 50 may be used to route air ducts 88.

- According to the control signal 25, which as discussed above has been generated
15 based on an indication that the front right seat 60 is occupied by the user 82, air vents 90 corresponding to the front right seat 60 are operated to generate a thermal curtain across the right side wall 48, and particularly the front right window 74. The right side wall 48 is the side wall closest to the user 82, and so it is this surface on which the thermal curtain 84 is formed. The thermal curtain 84 is generated on the part of the
20 side wall 48 closest to the user 82 for efficiency, although it will be appreciated that in some examples a thermal curtain may be generated across the entire side wall 48.

- In the example of Figures 3 to 5, as the rear right seat 64 is not occupied, no thermal curtain is generated across the part of the side wall 48 alongside the rear right seat 64.
25 This is to reduce energy wastage.

- In addition to forming the thermal curtain 84 on the side wall 48 as a barrier to conduction through the side wall 48, a thermal curtain may also be formed around the user 82 and seat 60 as a barrier to convection within the vehicle cabin 40. This curtain
30 would be formed by operating air vents 90 arranged around the seat 60.

Air vents may be configured to direct air flow through any surface in the vehicle cabin to the interior volume. For example, air vents may be provided in upper and/or lower surfaces of the cabin. Air vents provided in the lower surface are configured to direct

air upwards, while air vents provided in the upper surface are configured to direct air downwards. Where air vents are positioned in both the upper and lower surfaces of the vehicle cabin, air flow may be duplicated through the sets of vents, or may be varied according to the mode of operation. The provision of vents in both upper and lower
5 surfaces enhances the formation of a thermal curtain, particularly in examples where the vents in the upper and lower surfaces are vertically aligned.

Air flowing through vents in the upper and lower surfaces may be at different temperatures. For example, air flow through the vents in the upper surface may be at a
10 lower temperature than air flow through the vents in the lower surface of the cabin. In this way, hot air in the lower region of the cabin, which tends to rise, is replenished by the higher temperature air that is provided through the vents in the lower surface. In some examples, a first air flow apparatus is provided to provide air flow through the vents in the upper surface of the cabin, and a second air flow apparatus is provided to
15 provide air flow through the vents in the lower surface. The first and second air flow apparatuses may provide air flow at different temperatures.

In some examples, where air vents that act as outlets are provided in the one of the upper or lower surface of the cabin, air vents that act as inlets may be provided in the
20 other surface. In these examples, the inlets passively or actively draw air through the cabin from the outlets, leading to an increased air flow through the cabin.

In some examples, air outlets may also be operable as air inlets that passively or actively receive air flow from the cabin, depending on the control signal
25 from the controller.

Figure 6 illustrates an alternative vehicle cabin 100. The vehicle cabin 100 is a vehicle cabin for an autonomous vehicle, for example a self-driving car. The vehicle is therefore capable of operation with little or no user input. Autonomy is achieved by
30 sensing the surrounding environment and using a control system to interpret the sensed environment in order to navigate through it as a manually operated vehicle would. The independence of autonomous vehicles from user input during the entirety or the majority of a journey removes limitations on how the vehicle is configured, and so new exterior and interior vehicle design is possible. As a result, a driver is no longer

a requirement, and so the seating arrangement within the autonomous vehicle cabin 100 may be highly variable.

Each seat 102, 104, 106, 108 in the cabin 100 is movable to a plurality of positions.

5 The seats are considered movable by virtue of being able to have their configuration altered, as in conventional vehicles, but also may have their rotation/orientation and/or location altered. Moving a seat may be performed manually or automatically. Seats may rotate about vertical axes to face other each, for example, and may rotate about horizontal axes to recline or fold. A conventional vehicle air conditioning system having
10 manually controlled air outlets disposed in the dashboard may be inadequate for use with such a seating arrangement.

In the arrangement in Figure 6, the front left and rear right seats 104, 106, are in a conventional seating position; they are facing the forward direction of travel T, their
15 configuration is a default configuration, and their location has not been changed. A seat is 'facing' a direction of travel if an occupant seated in that seat would be facing the direction of travel. This conventional position may be considered to be the 'default' position of the seats.

20 The front right seat 102 is rotated approximately 190 degrees from its default position to face in the opposite direction to the forward direction T. The rear left seat 108 has had its location changed from the default position and is now located further towards the rear wall 46 than it is in the default position. The default location of the rear left seat 108 is illustrated by a dashed line in Figure 6.

25

The front right and rear left and right seats 102, 106, 108 are occupied as the users 110, 112, 114 are seated on them. As a result, the air flow system 20 operates to form thermal curtains 116, 118 over regions of the side walls 48, 50 that are alongside a seated user. As two of the users 110, 112 are seated alongside the right side wall 48,
30 a thermal curtain 116 is formed over the entirety of the right side wall 48. Where both the rear and front seats are occupied on the same side of the vehicle, a thermal curtain may be generated down the whole side wall of the vehicle cabin, as depicted here. In these examples, the thermal curtain spans also the B-pillar between the front and rear row seats. It may also be possible, however, to selectively activate only certain ones of

the air flow vents so that two distinct thermal curtains are generated on one side of the vehicle, providing a further benefit for energy efficiency.

As one user 114 is seated alongside the left side wall 50, a thermal curtain 118 is
5 formed over the left side wall 50 alongside the rear left seat 108 but not alongside the front left seat 104. The region over which the thermal curtain 118 alongside the user 114 in the rear left seat 108 is formed is shifted rearward because the location of the rear left seat 108 has been shifted rearward. The location of a thermal curtain may be altered depending on the location, position, or configuration of each seat. In some
10 examples, if the seat is rotated to face away from a side wall, the system may deem that forming a thermal curtain over the side wall is unnecessary. The thermal curtain can be 'shifted' forwards or rearwards by activating the relevant selected ones of the air flow vents to ensure the thermal curtain exists only in the region adjacent to where the user is actually seated.

15

Figure 7 illustrates a method of operation 120 of the air flow system 20. With reference to the seating arrangement of Figures 3 to 5, the method 120 comprises receiving (step 122), at the controller 24, a seat signal indicating that a seat 60, 62, 64, 66 within the vehicle cabin 40 is occupied. The controller 24 generates 124 a control signal 25 to
20 communicate to the air flow apparatus 28. The air flow apparatus 28 is subsequently controlled 126 according to the control signal 25 to generate a thermal curtain 84 by activating only those air vents which are required to generate a thermal curtain adjacent to a seated passenger.

25 In examples where seats are also capable of relocation in the cabin, the position sensors also comprise location sensors, and the controller is configured to control the air flow system based on the location of each occupied seat within the cabin. For example, the controller may assign a group of vents to be operated to provide air flow to a relocated occupied seat, where air flow through those vents would provide air flow
30 only to the seat and within a predetermined distance or area around the seat.

In another example, as an alternative to using individual location, orientation and/or configuration sensors associated with the seat, the position sensors may comprise at least one camera that obtains image frames relating to one or more seats in the cabin.

The controller analyses the image frames to update a three-dimensional model of the vehicle interior to determine the position of the occupied seat within the reference system formed by the vehicle cabin.

- 5 In some examples, the vehicle is a semi-autonomous vehicle. In other examples, the vehicle is a manual vehicle. The invention is applicable to a vehicle driven by any source of motive power, including battery drive vehicles and engine driven vehicles, as well as hybrid vehicles.
- 10 It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application.

CLAIMS

1. A vehicle system for use in a vehicle, the vehicle system including a vehicle cabin defined, at least in part, by an upper cabin surface, a lower cabin surface and a side wall, the vehicle cabin having a seat adjacent to the side wall, and an air flow system comprising;

at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface;

10

an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to generate a thermal curtain across the side wall; and

15

a control system comprising one or more controller(s) configured to: receive a seat signal relating to whether or not the vehicle seat is occupied; generate a control signal to control the airflow through the at least one air vent in dependence on the seat signal; and output the control signal so as to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.

20

2. The vehicle system as claimed in claim 1, wherein the at least one air vent is configured to direct the airflow in a substantially vertical direction across the side wall.

25

3. The vehicle system as claimed in claim 1, wherein the at least one air vent is configured to direct the airflow in a substantially horizontal direction across the side wall.

4. The vehicle system as claimed in any of claims 1 to 3, comprising a first airflow apparatus configured to direct a first airflow through at least one upper air vent in the upper cabin surface and a second air flow apparatus configured to direct a second airflow through at least one lower air vent in the lower cabin surface, the upper and

30

lower air vents being configured to direct airflows towards one another across said side wall.

5 5. The vehicle system as claimed in claim 4, wherein the first airflow apparatus is configured to direct an air flow at a lower temperature than an air flow directed by the second air flow apparatus.

10 6. The vehicle system as claimed in claim 4, wherein the first airflow apparatus is configured to direct an airflow at a greater temperature than an airflow directed by the second airflow apparatus.

15 7. The vehicle system as claimed in any of claims 1 to 3, comprising a first airflow apparatus configured to direct a first airflow to at least one upper air vent in the upper cabin surface and a second air flow apparatus configured to provide suction that draws the first airflow across said side wall into at least one lower air vent in the lower cabin surface.

20 8. The vehicle system as claimed in any of claims 1 to 3, comprising a first airflow apparatus configured to direct a first airflow to at least one lower air vent in the lower cabin surface and a second air flow apparatus configured to provide suction that draws the first airflow across said side wall into at least one upper air vent in the upper cabin surface.

25 9. The vehicle system as claimed in any of claims 4 to 8, wherein the at least one upper air vent and the at least one lower air vent are in vertical alignment with one another.

30 10. A control system for an air flow system of a vehicle, the vehicle having a vehicle cabin defined, at least in part, by an upper cabin surface, a lower cabin surface and a side wall the vehicle having:

 a seat adjacent to the side wall;

 at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface and

an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to generate a thermal curtain across the side wall;

5 the control system comprising one or more controllers configured to:

receive a seat signal relating to whether or not the vehicle seat is occupied;

generate a control signal to control the airflow through the at least one air vent in dependence on the seat signal; and

10 output the control signal so as to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.

11. The control system according to claim 10, wherein the one or more controllers collectively may comprise:

15 at least one electronic processor having one or more electrical inputs for receiving the seat signal; and

at least one electronic memory device operatively coupled to the at least one electronic processor and having instructions stored therein;

20 wherein the at least one electronic processor is configured to access the at least one memory device and execute the instructions stored therein so as to generate the control signal.

12. The control system of claims 10 or 11, wherein the one or more controllers are configured to receive a temperature signal indicative of an air cabin temperature, and
25 output the control signal in dependence on the temperature signal.

13. The control system according to any of claims 10 to 12, wherein the one or more controllers are configured to receive a user preference signal indicative of an air cabin temperature, and output the control signal in dependence on the user preference
30 signal.

14. The control system according to any of claims 10 to 13, wherein the one or more controllers are configured to receive a seat signal indicative of the position of the seat, and output the control signal in dependence on the seat signal.

15. A vehicle comprising the vehicle system as claimed in any of claims 1 to 9 or the control system as claimed in any of claims 10 to 14.
- 5 16. The vehicle as claimed in claim 15, wherein the side wall is a vehicle door.
17. The vehicle as claimed in claim 16, wherein the vehicle door includes a glass window across which the thermal curtain is generated.
- 10 18. The vehicle as claimed in claim 17, wherein the at least one upper air vent is disposed in a cant rail of the vehicle.
19. A method of controlling an air flow system for a vehicle having a vehicle cabin defined, at least in part, by an upper cabin surface, a lower cabin surface and a side wall, the vehicle having:
- 15 a seat adjacent to the side wall;
at least one air vent disposed in at least one of the upper cabin surface and the lower cabin surface; and
an airflow apparatus configured to direct an airflow through the at least one air vent, wherein the at least one air vent is configured to generate an airflow across the side wall so as to generate a thermal curtain across the side wall;
the method comprising:
receiving a seat signal relating to whether or not the vehicle seat is
25 occupied;
generating a control signal to control the airflow through the at least one air vent in dependence on the seat signal; and
outputting the control signal so as to generate the thermal curtain across the side wall if the seat adjacent to the side wall is occupied.
- 30 20. Computer software that, when executed by one or more processors, causes performance of a method according to claim 19.

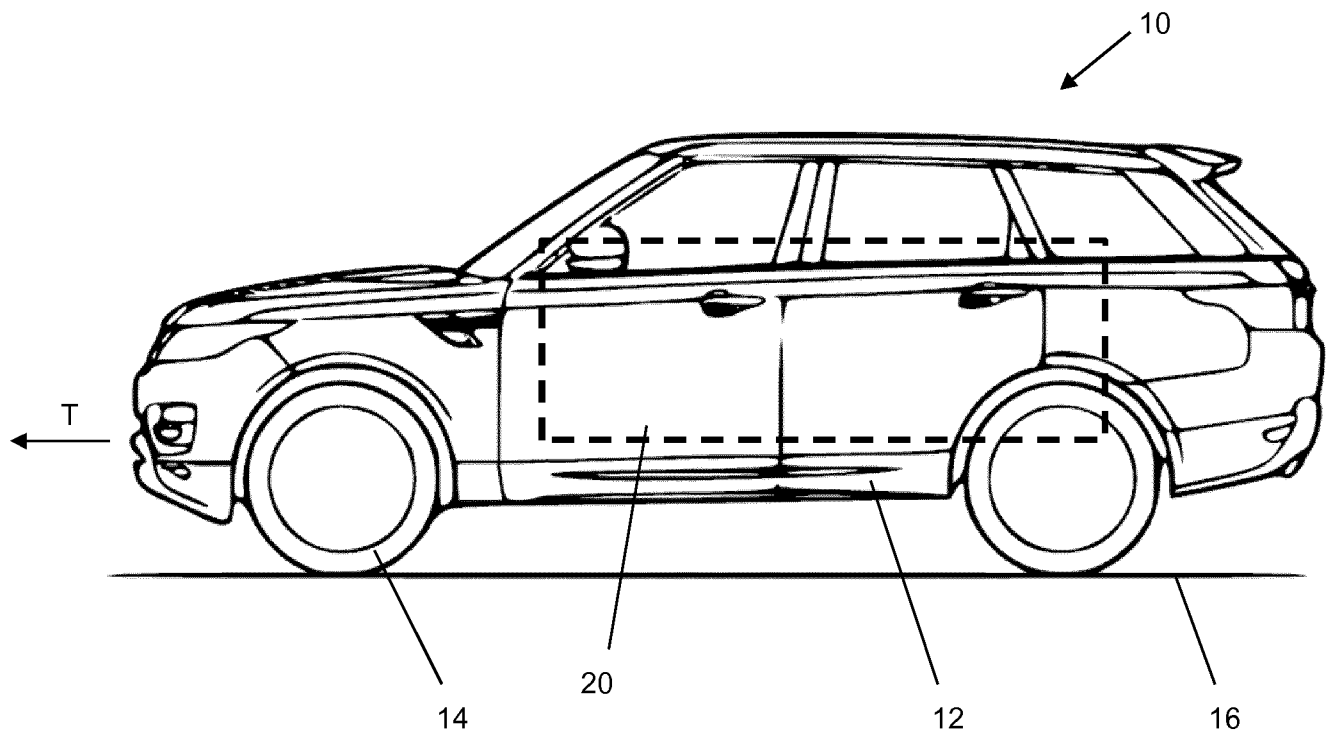


Fig. 1

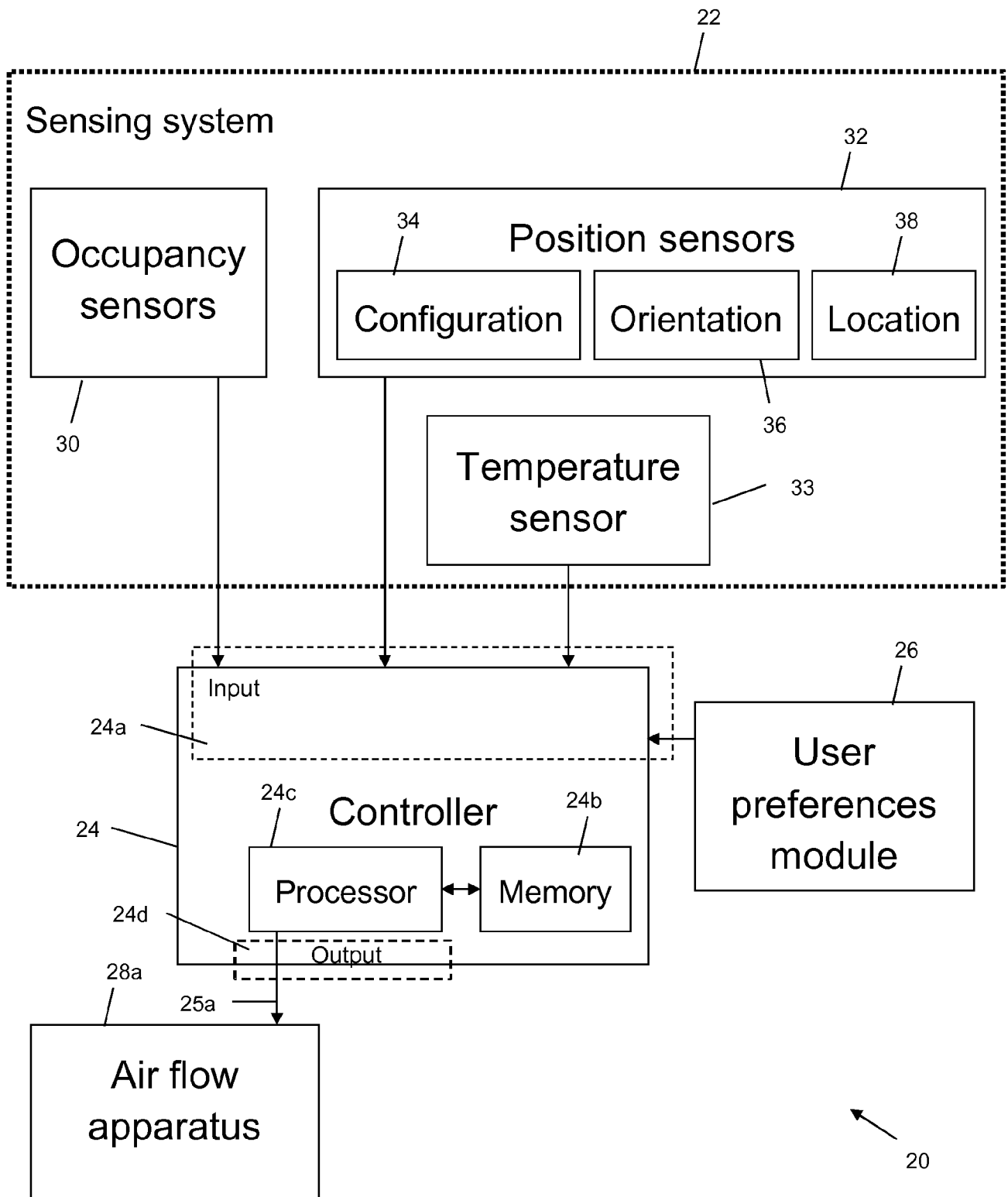


Fig. 2

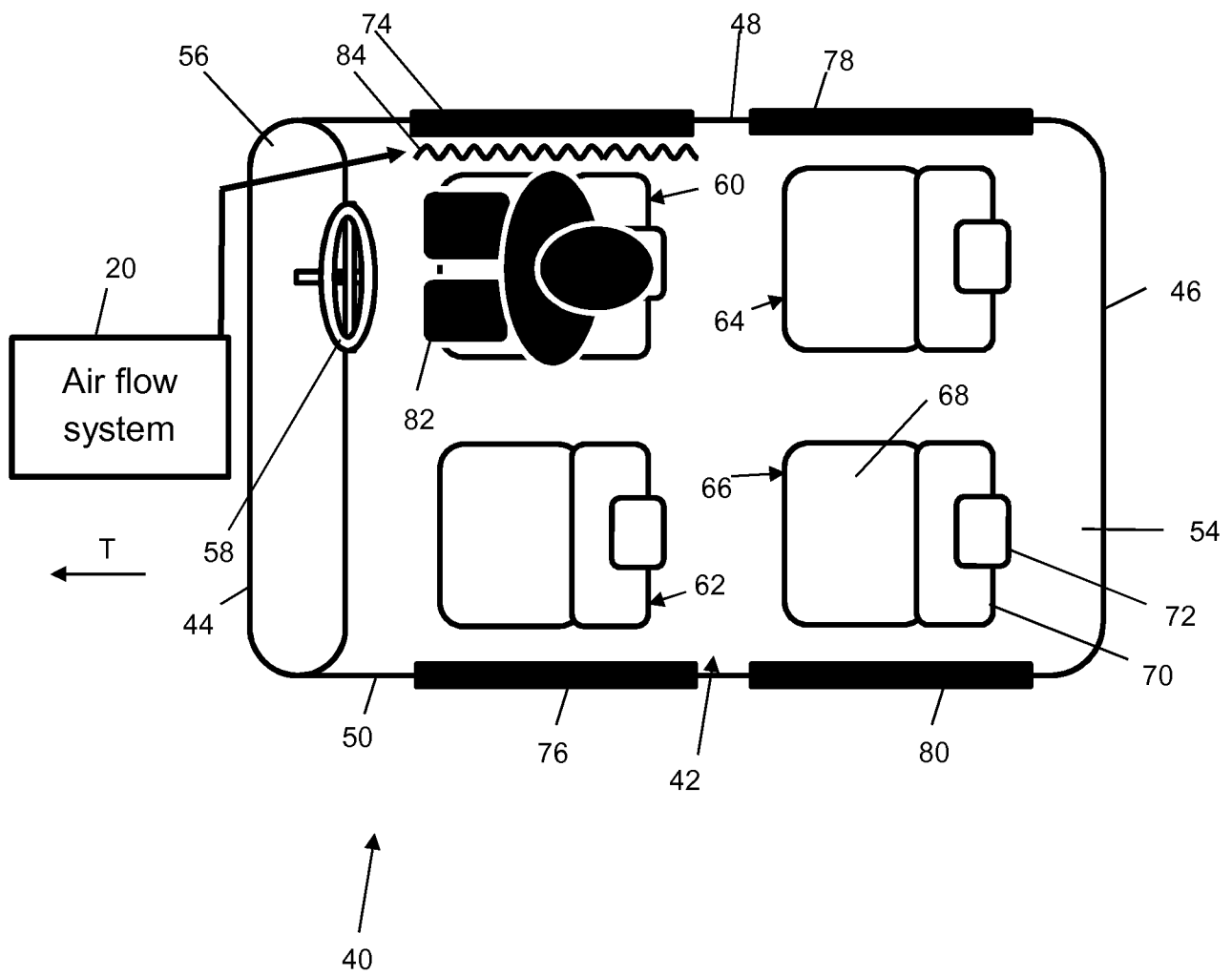


Fig. 3

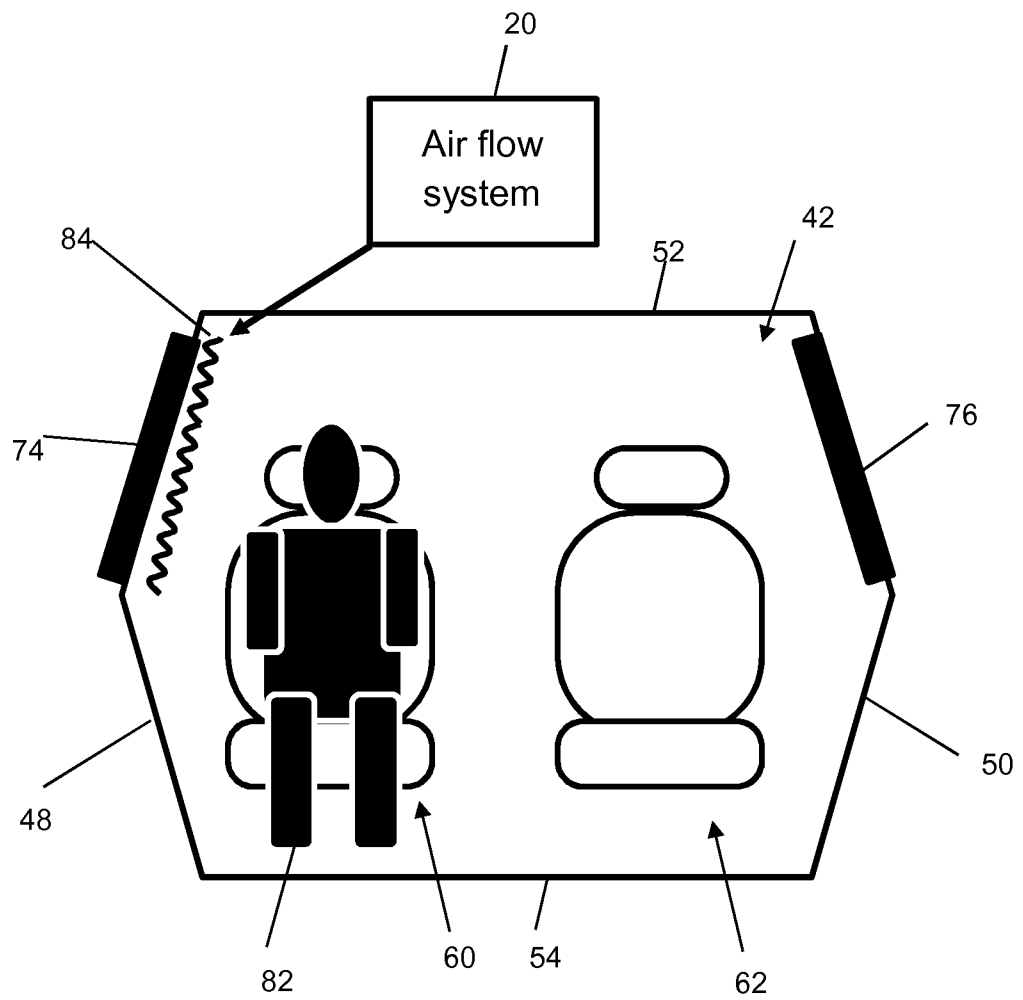


Fig. 4

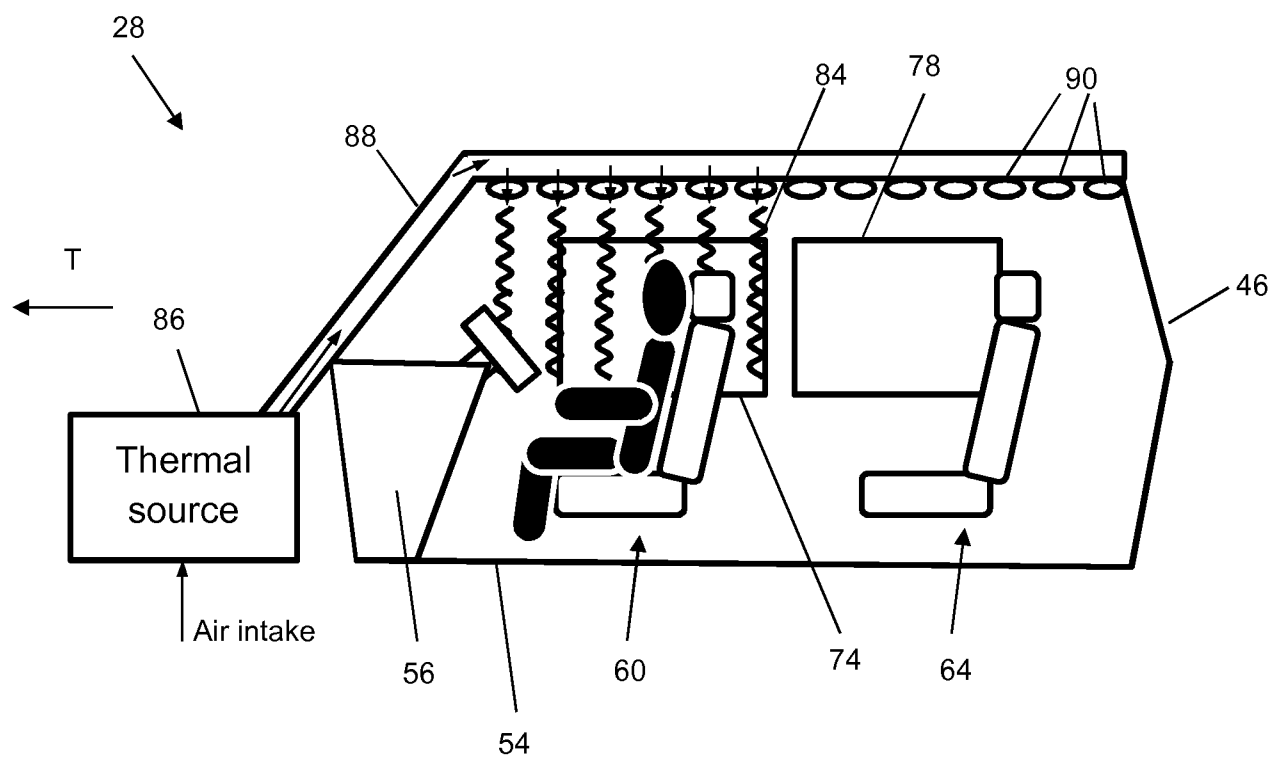


Fig. 5

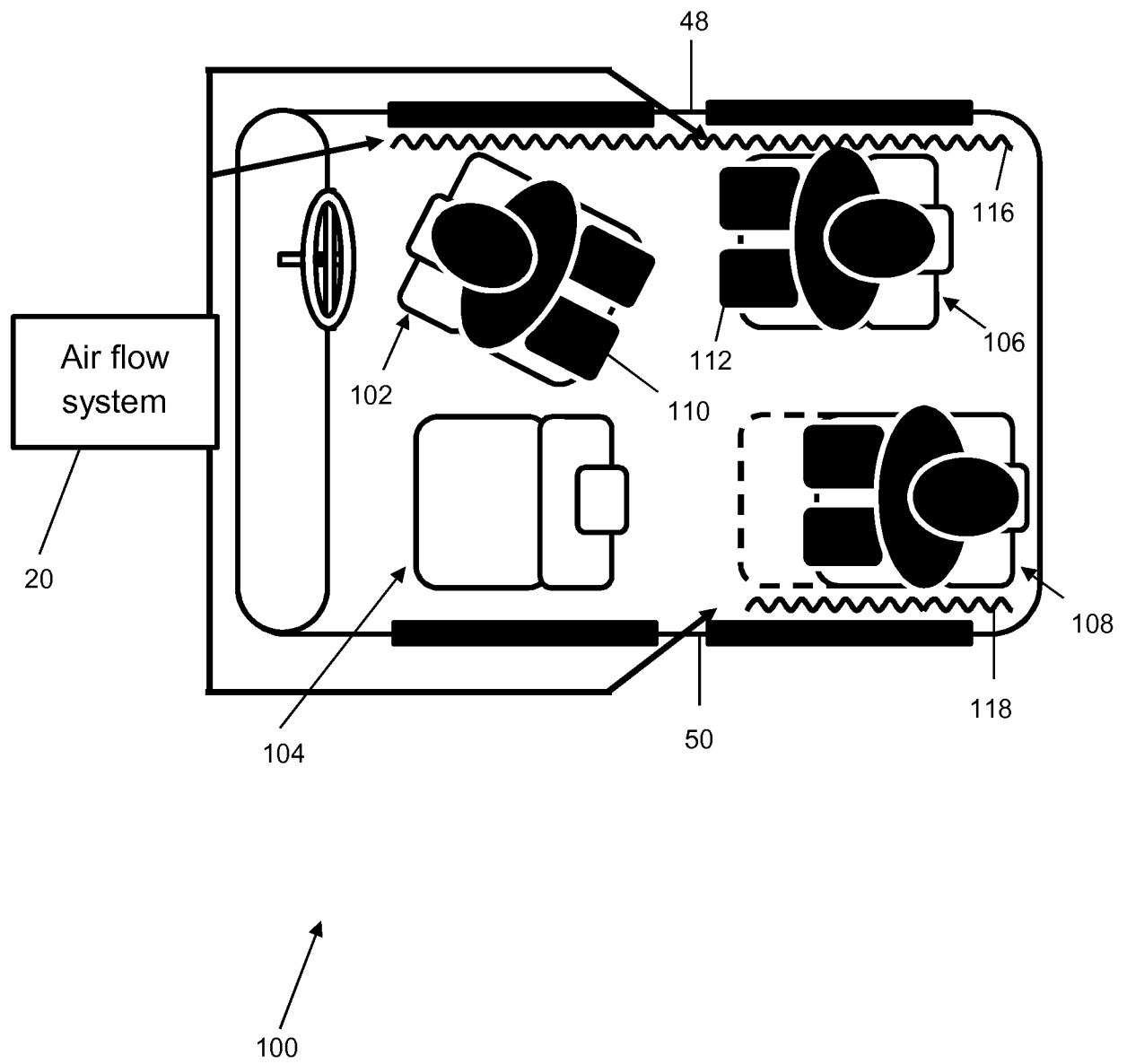


Fig. 6

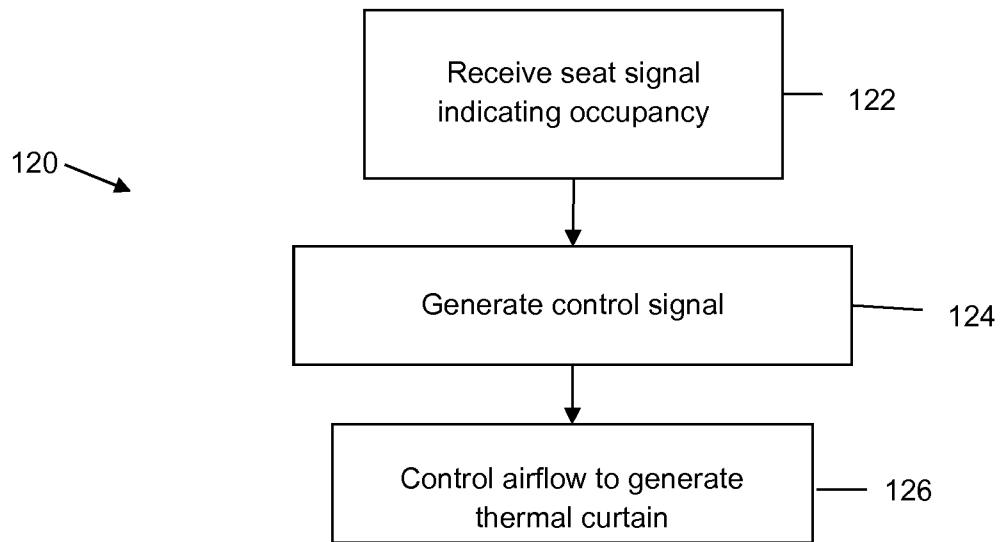


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/078275

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60H1/00 B60H1/24
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)
B60H

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H07 156647 A (NIPPON DENSO CO) 20 June 1995 (1995-06-20) paragraphs [0015] - [0055]; figures 1-11 -----	1-20
X	DE 10 2017 003550 A1 (DAIMLER AG [DE]) 18 October 2018 (2018-10-18) paragraphs [0006] - [0010], [0026] - [0077]; figures 1-7 -----	1-20
A	JP 2018 043727 A (TOYOTA AUTO BODY CO LTD) 22 March 2018 (2018-03-22) paragraphs [0022] - [0097]; figures 1-14 -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

16 January 2020

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Flori, Massimiliano

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/078275

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H07156647 A	20-06-1995	JP 3284710 B2	20-05-2002
		JP H07156647 A	20-06-1995

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