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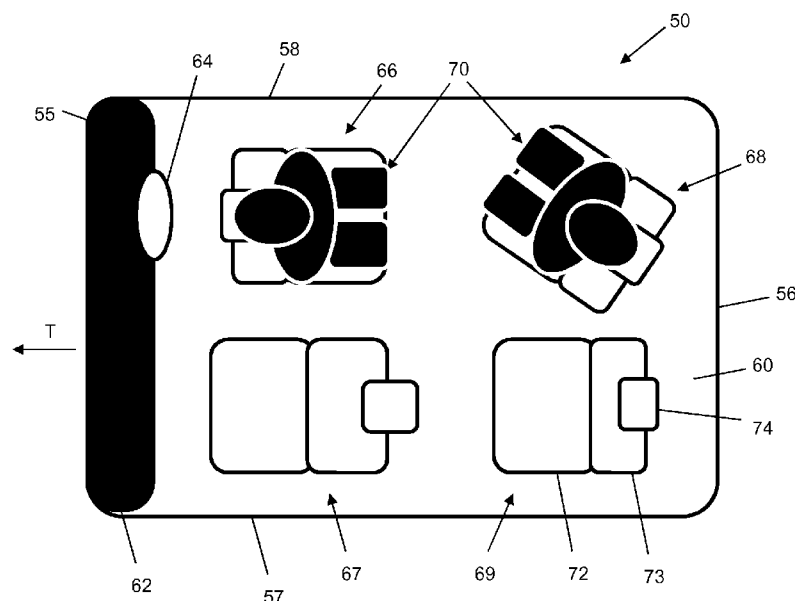


Fig. 2

(57) Abstract: A vehicle system comprising a vehicle cabin (50) provided with an air flow system and a seat (66, 67, 68, 69) for a user of the vehicle, the seat (66, 67, 68, 69) being moveable into a plurality of positions the air flow system comprises a plurality of air vents, an air flow apparatus configured to selectively direct an air flow through each of the plurality of air vents, and a controller comprising a first input configured to receive an occupancy signal indicative that a user is seated in the seat (66, 67, 68, 69), a second input configured to receive a seat signal indicative of the position of the seat (66, 67, 68, 69), and an output for providing a control signal to the air flow apparatus to selectively control which of the plurality of air vents directs the air flow through in dependence on the occupancy signal and in dependence on the seat signal.



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A VEHICLE SYSTEM

TECHNICAL FIELD

- 5 The present disclosure relates to vehicle air flow systems. Aspects of the invention 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.

10 BACKGROUND

- In conventional vehicles, seating is arranged so that occupants face a vehicle dashboard. In conventional vehicle air conditioning systems, air vents are disposed around the vehicle dashboard and, more recently, vents are also disposed between
15 front and second row seats of the vehicle. This configuration is preferred because the range of movement of the occupants with relation to the vents is limited.

- However, these air conditioning systems dispense thermally conditioned air across the cabin space, thermally conditioning large areas of the vehicle. Such air conditioning
20 systems consume large quantities of energy, which is a particular issue in battery electric vehicles (BEV), because consuming large quantities of energy significantly impacts the range of a BEV.

- Furthermore, for non-conventional seating arrangements arranging air vents in the
25 dashboard is ineffective.

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

30 SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a vehicle system provided with a vehicle cabin, an air flow system and at least one seat, a control system for an air flow system, a vehicle comprising the vehicle cabin and/or the control system, a method,

computer software and a computer readable medium as claimed in the appended claims.

5 According to an aspect of the present invention there is provided a vehicle system for use in a vehicle, the vehicle system comprising a vehicle cabin provided with an air flow system and a seat for a user of the vehicle. The seat is moveable into a plurality of positions. The air flow system comprises: a plurality of air vents and an air flow apparatus configured to selectively direct an air flow through each of the plurality of air vents. The vehicle system further comprises a control system comprising one or more
10 controllers configured to: receive an occupancy signal indicative that a user is seated in the seat, receive a seat signal indicative of the position of the seat, and output a control signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in dependence on the occupancy signal and in dependence on the seat signal.

15

The vehicle system usefully provides efficient and directed air conditioning for users by focussing the air flow according to where and how the user is sat. Controlling air flow based on a combination of the occupation and position of a vehicle seat permits air conditioning of a targeted volume of the vehicle. As a result, efficiency is improved as
20 wasteful conditioning of the entire cabin volume is reduced. The vehicle cabin may be used in manual, semi-autonomous, or autonomous vehicles.

The vehicle cabin may comprise a plurality of seats. Each seat may be moveable into a plurality of positions.

25

The seat or seats may be moveable into each of the plurality of positions by one or more of: longitudinal movement; lateral movement; rotational movement; reclining movement; and vertical movement. The longitudinal movement, lateral movement, rotational movement, reclining movement, and/or vertical movement may be with
30 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.

5

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 the user, while reducing energy wastage by optimising air flow for the user.

10

The air flow apparatus may comprise one or more of: a pump for generating air flow; a thermal source for thermally conditioning air; and a valve system for controlling air flow. The valve system may comprise a valve positioned at each of the vents.

15 The vehicle system may comprise at least one position sensor configured to provide the seat signal.

The vehicle system may comprise at least one air vent configured to direct an airflow downwards. The vehicle system may comprise at least one air vent configured to
20 direct an airflow upwards. The vehicle system may comprise air vents disposed around vehicle cabin. For example, the vehicle system may comprise air vents disposed around the vehicle so as to provide an air flow to a front of the vehicle seat in each position. Alternatively or in addition, the vehicle system may comprise one or more first air vents associated with a default, or first, position of the vehicle seat and one or more
25 second air vents associated with an additional, or second, position of the vehicle seat.

The vehicle cabin may be defined at least in part by an upper cabin surface and a lower cabin surface. At least one of the plurality of air vents may be disposed in the upper cabin surface. At least one of the plurality of air vents may be disposed in the
30 lower cabin surface. At least one of the plurality of air vents may be bi-directional, so that it can act as an inlet or an outlet to the vehicle cabin.

Disposing air vents in an upper and/or lower surface of the vehicle cabin results in an improvement in the ability of the air flow system to provide a targeted air flow towards

the occupied seat quickly and efficiently. The combined effect of air vents in the upper and/or lower cabin surface, and basing the control signal on position and occupation of seats, permits air flow to be focussed towards a distinct region within the vehicle cabin.

- 5 The vehicle cabin may comprise a first air flow apparatus configured to direct a first air flow through at least one upper air vent in the upper cabin surface. The vehicle cabin may comprise a second air flow apparatus configured to direct an air flow through at least one lower air vent in the lower cabin surface. The upper and lower air vents may be configured to direct airflows towards one another to create a thermal curtain within
10 the vehicle cabin. The upper and lower air vents may be configured to direct opposed airflows.

Creating a thermal curtain can advantageously limit convection between different regions of the vehicle. The air flow through the vents effectively operates as a barrier
15 between regions so that different conditions can be implemented in the different regions of the vehicle. In some examples, a single air flow apparatus may create a thermal curtain. Air vents in one surface may also be used to create a thermal curtain.

In an example, the thermal curtain may act as a thermal barrier that reduces energy
20 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
25 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
30 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
5 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.

In one example, the first air flow apparatus may be configured to direct an airflow
10 which is at a lower temperature than an airflow 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.

15 The first air flow apparatus may be configured to direct an airflow which is at a lower temperature than the cabin air temperature. The cabin air temperature may be detected using one or more temperature sensors.

The one or more controllers may be configured to receive a temperature demand
20 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
25 temperature demand signal and the temperature signal. The temperature demand signal may be indicative of the cabin air temperature.

In another embodiment, the first air flow apparatus may be configured to direct an
30 airflow which is at a higher temperature than an airflow directed by the second air flow apparatus.

The at least one upper air vent and the at least one lower air vent may be in vertical alignment with one another. The alignment of air vents promotes the formation of a thermal curtain.

The controller may be configured to provide a control signal to adjust automatically a status of one or more of the plurality of air vents in response to the seat signal. The status of the one or more of the plurality of air vents may comprise an open status and
5 a closed status. The open status may indicate full air flow through the vent. The closed status may indicate no air flow through the vent.

The vehicle system may comprise a user preference module for providing user preference data to the controller. The controller may be configured to provide a control
10 signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in dependence on the occupancy signal, on the seat signal, and on the user preference data.

The user preference data may include at least one of a temperature of the air flow and
15 a speed of the air flow. The inclusion of user preference data in addition to the adaptation of the air flow system to occupation and position further improves the user experience.

According to another aspect of the invention, there is provided a control system for an
20 air flow system for a vehicle system comprising a vehicle cabin having a vehicle seat, the vehicle seat being moveable into a plurality of positions, the air flow system having a plurality of air vents and an airflow apparatus configured to selectively direct an airflow through each of the plurality of air vents, the control system comprising one or more controllers configured to: receive an occupancy signal indicative that a user is
25 seated in the seat; receive a seat signal indicative of the position of the seat; and output a control signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in dependence on the occupancy signal and in dependence on the seat signal.

30 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.

Any controller or controllers described herein may suitably comprise a control unit or
5 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.

As used herein the term “controller” or “control unit” will be understood to include both
10 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 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
15 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 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
20 as the first controller. Other suitable arrangements may also be used.

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
25 user preference signal indicative of an air cabin temperature, and output the control signal in dependence on the user preference signal.

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

30

According to another aspect of the invention, there is provided a method of controlling an air flow system for a vehicle system comprising a vehicle cabin having a vehicle seat, the vehicle seat being moveable into a plurality of positions, the air flow system having a plurality of air vents and an airflow apparatus configured to selectively direct

an airflow through each of the plurality of air vents. The method comprises: receiving an occupancy signal indicative that a user is seated in the seat; receiving a seat signal indicative of the position of the seat; providing a control signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in
5 dependence on the occupancy signal and in dependence on the seat signal; and selectively directing an air flow through the air vents according to the control 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
10 according to a preceding aspect of the invention.

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.
15 Optionally, the computer readable medium comprises a non-transitory computer readable medium.

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
20 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.

25 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:

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

Figure 2 shows a schematic plan view of a seating arrangement of a vehicle cabin of the vehicle of Figure 1;

Figure 3 shows a schematic plan view of air vents within a vehicle cabin in relation to the seating arrangement of Figure 2;

5 **Figure 4** shows a schematic side view of a vehicle cabin of the vehicle of Figure 1;

Figure 5 shows a schematic diagram of an air flow system for use in controlling air vents within the vehicle cabin in Figures 3 and 4;

10

Figure 6 shows a schematic plan view of an alternative seating arrangement of a vehicle cabin of the vehicle of Figure 1; and

Figure 7 shows a method of operation of the air flow system of Figure 5.

15

DETAILED DESCRIPTION

Figure 1 illustrates a side view of an autonomous vehicle 10. The vehicle 10 has a vehicle body 12 supported on a plurality of wheels 14. A vehicle cabin is defined within the vehicle body 12 within which passengers of the vehicle can be accommodated. 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, when in a reverse gear.

25

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, as shown in Figure 1. A lower surface of the vehicle is closer to the ground than an upper surface of the vehicle when the vehicle is supported by the wheels. The ground 16 may be used as a reference point as shown in Figure 1.

30

The vehicle 10 is an autonomous vehicle, for example a self-driving car. It is therefore capable of operation with little or no user input. Autonomy is achieved by 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. Altering conventional vehicle design requires re-engineering of vehicle systems, and an example of a re-engineered vehicle cabin and its air conditioning system for an autonomous vehicle is the subject of the following description.

More specifically, incorporating a highly variable seating arrangement into autonomous vehicles renders inadequate conventional vehicle air conditioning systems, where air vents are disposed in the dashboard and controlled manually. For example, one problem arises because, if a seat of an autonomous vehicle is rotated away from its default orientation, then the conventional air flow system is incapable of adaptation and the air vents in the vehicle dashboard deliver thermally conditioned air onto a rear surface of the seat. This reduces the ability of the air conditioning system to provide effective thermal comfort control.

To improve the effectiveness of the air conditioning within the autonomous vehicle 10, the vehicle is provided with a system comprising a controller and an air flow system which is adaptable based on the arrangement of users and the seating in the vehicle. In general, the controller receives inputs relating to both occupancy and the seating arrangement and generates output signals that cause the air flow system to thermally condition particular regions of the vehicle cabin based on the received inputs by operation of selected vents.

An example vehicle cabin 50 along with occupants and an example seating arrangement is illustrated in Figure 2. As will be discussed in relation to Figures 3 to 5, the cabin 50 incorporates an air flow system 150. The air flow system 150 comprises an air flow apparatus 158 controlled by a controller 160 to provide effective and efficient thermal conditioning for users occupying the cabin 50, the desired effect achieved by adapting operation of the air flow apparatus 158 according to occupants and the position of their seat(s). Figures 2, 3, 4, and 5 illustrate two schematic plan

views of the cabin 50, a side view of the cabin 50, and the air flow system 150 for control of air flow respectively.

The cabin 50 is an enclosed interior volume of the vehicle, defined by the vehicle body
5 12. Taking T as a reference direction, the cabin 50 is surrounded and defined by
respective interior surfaces of front and rear walls 55, 56, left and right side walls 57,
58, a roof, and a floor of the vehicle body 12. As shown in Figure 2, the front and rear
surfaces of the front and rear walls, 55, 56 respectively, are substantially perpendicular
to T. The left and right side walls 57, 58 are substantially parallel to T. The roof
10 extends between the upper edges of the side walls 57, 58, above the cabin interior
when the vehicle is in the orientation of Figure 1, and defines an upper surface 59. The
floor extends between the lower edges of the side walls 57, 58, below the cabin interior
when the vehicle is in the orientation of Figure 1, and defines a lower surface 60.

15 Within the cabin 50, a dashboard 62 extends along and is positioned adjacent the front
surface 55. In Figure 2, the dashboard 62 includes a steering wheel 64 for use by a
driver when the vehicle 10 is operating in a non-autonomous mode. However, it will be
appreciated that a steering wheel is not a requirement in a fully autonomous vehicle
and so may be omitted in some examples. The dashboard 62 may additionally, or
20 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. In some autonomous vehicles, the dashboard
may be omitted entirely.

25

Disposed within the interior of the cabin 50 are four seats. Using direction T as a
reference, the four seats are: a front right seat 66; a front left seat 67; a rear right seat
68; and a rear left seat 69. Although Figures 2 to 4 are only schematic diagrams, it can
be seen that each seat comprises a seat portion 72, a back 73, and a headrest 74, as
30 is conventional for vehicle seats. The seats are mounted to the lower surface 60 of the
cabin by a mounting, which is not depicted in these schematics. Seats may also
include a foot rest and/or one or more arm rests.

Each seat 66, 67, 68, 69 is movable to a plurality of positions. The seats are considered movable by virtue of being able to have their configuration, rotation/orientation, and/or location altered. Moving a seat may be performed manually or automatically. The term 'configuration' is intended to encompass at least one of: a
5 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 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
10 is folded up. 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.

In the arrangement in Figure 2, the rear left seat 69 is in a conventional seating
15 position; it is facing the forward direction of travel T, is in its default position and is not reclined or reconfigured. 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 66 is rotated 180 degrees from its default position to face in the opposite direction to the forward direction T. The rear right seat 68 is rotated through an angle of approximately 45 degrees towards the right surface 58 of the cabin 50. The front left seat 67 is facing the direction T, so is not rotated from its default position, and is partially reclined. The front and rear right seats 66, 68 are occupied by users
25 that are seated on them.

The position and occupancy status of each seat 66, 67, 68, 69 is monitored by a sensing system 152 (see Figure 5). The sensing system 152 is capable of generating signals indicative of the occupancy and/or position of each seat 66, 67, 68, 69. In other
30 words, the sensing system 152 outputs signals which a determination can be made about the position of each seat and whether or not each seat is occupied.

The sensing system 152 comprises occupancy sensors 154. Occupancy sensors are usually associated with one seat, and monitor the occupancy status of that seat. In

some examples, an occupancy sensor may monitor more than one seat, and so the sensing system 152 may include a single occupancy sensor to monitor all seats.

5 The sensing system also comprises position sensors 156 that monitor the position of each seat 66, 67, 68, 69 within the cabin 50. The position sensors 156 comprise configuration sensors 170, rotation/orientation sensors 172, and/or location sensors 174. The sensing system 152 may include a single position sensor only in some examples. Various seat position and/or occupancy sensors as known in the art may be used.

10

The sensing system 152 comprises at least one temperature sensor 153 configured to provide to the controller a temperature signal indicative of a temperature of the cabin. A temperature demand signal may be received

15 In some examples, the occupancy sensors 154 may generate a signal only when a seat is occupied, while in other examples, the occupancy sensors 154 may generate a signal when the seat is unoccupied. Similarly, the position sensors 156 may generate signals based on the position of each seat 66, 67, 68, 69 relative to a default position, relative to the sensor, or relative to a coordinate system generated for the cabin 50.

20

In one example, each occupancy sensor 154 is a pressure sensor in a respective seat. The position sensors 156 may be individual sensors configured to measure different position parameters. Position parameters include: 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
25 50; a head rest position of the seat; a position of a foot rest and/or an arm rest; an orientation of the seat; and/or a location of the seat within the cabin 50. A camera or a plurality of cameras may be used in other examples as the occupancy and/or position sensors or in addition to the occupancy and position sensors, where image frames obtained by the camera are used to analyse the seat position and its occupancy
30 based, for example, on a three-dimensional model.

In the example of Figure 5, the occupancy sensors 154 and position sensors 156 are separate sensors, although it will be appreciated that in other examples at least some of the occupancy sensors and position sensors may be combined.

The cabin 50 incorporates an air flow system 150 to provide effective air flow to users of the vehicle based on the generated signals. The air flow system 150 comprises an air flow apparatus 158 and a plurality of air vents 162. An example arrangement of the air vents 162 in a cabin 50 is shown in Figure 3, and the air flow apparatus 158 in relation to the cabin 50 is shown in Figure 4. In both Figures 3 and 4, a plurality of air vents 162 are positioned in the upper surface 59 of the cabin 50. For continuity, the seats of the cabin shown in Figures 3 and 4 are in the same positions as those in Figure 2, although the front and rear left seats 67 are not shown in Figure 4 for clarity.

The air flow apparatus 158 comprises a thermal source 164 configured to thermally condition air and to supply it to the plurality of air vents 162. The thermal source 164 is capable of heating or cooling air it receives, in order to provide air to vents 162 at a predetermined temperature. The thermal source 164 may provide air to different air vents 162 at different temperatures. 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.

The air flow apparatus 158 also comprises a pump mechanism (not shown in the Figures), to deliver air from the thermal source 164 to the vents 162, and to draw air into the thermal source 164. In use, the pump mechanism may direct air from the thermal source 164 through air ducts 166 towards the air vents 162, which act as air outlets. The air ducts 166 are illustrated schematically in Figure 4 as being positioned along a pillar of the front and surface 55 of the cabin 50, although it will be appreciated that the ducts 166 may be routed in any appropriate way.

The air vents 162 direct air flow into the vehicle cabin 50 in the region of the vehicle users. The air vents 162 are provided in upper surface 59 of the cabin 50, although it will be appreciated that the vents may alternatively or additionally be provided in the lower surface 60 of the cabin 50. This arrangement will be discussed later.

The air vents 162 of Figure 3 are positioned relative to each of the seats 66, 67, 68, 69. Taking the rear left seat 69 as an example, it can be seen that the air vents 162

are arranged around the seat's default position. The arrangements shown here are not intended to be limiting, and any arrangement of air vents is possible.

Although not shown in the Figures, the air flow apparatus 158 incorporates at least one
5 mechanism for regulating and selectively controlling the flow of air through the vents 162. A valve may be provided at each vent to prevent or partially prevent air flow. The valve may be manually or automatically controllable according to a status of the vent. The controller may be configured to provide a control signal to adjust automatically a status of one or more of the plurality of air vents or the valves in response to the seat
10 signal. The status of the one or more of the plurality of air vents may comprise an open status and a closed status. The open status may entail full air flow through the vent. The closed status may entail no air flow through the vent. 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 50. It is envisaged that at least subsets of
15 air vents will be controllable, either by control of valves at the vents, by control of valves positioned in the ducts, or by a combination of valves at the vents and within the ducts. An example of subsets of vents is shown by dashed squares in Figure 3, so that each seat is effectively zoned.

20 By allocating air vents 162 into seat-specific groups, the air flow from those vents is controllable by a controller according to an occupancy signal and a position signal received from the sensing system to achieve an effective air flow for each user.

In some examples, the direction of air flow from the vents 162 may be manually or
25 automatically controllable. A valve provided for an vent to prevent or partially prevent air flow may have a dual purpose of regulating the air flow through an vent and directing the air through it (i.e. a valve may be partially open).

The cabin 50 further includes a controller 160, for automatically controlling the air flow
30 apparatus 158 according to the occupancy and position signals received from the sensing system 152. The controller 160 comprises at least: an input 160a configured to receive one or more input signals; a memory 160b storing instructions and/or data; a processor 160c configured to access the memory and to process the or each input signal based on the instructions and/or data contained in the memory to generate one

or more control signals, for example by implementing one or more algorithms; and an output 160d configured to transmit the control signals generated by the processor.

5 The controller 160 receives input signals from the occupancy sensors 154 and the position sensors 156. The position sensors 156 provide an indication of an orientation and configuration of a seat 66, 67, 68, 69, and optionally a location of the seat 66, 67, 68, 69. Based on each of these input signals, and any user preferences stored in user preference module 168, the controller 160 generates and sends a control signal 176 to the air flow apparatus 158. User preferences stored in the user preference module 168
10 may include at least one of a speed of the air flow, a temperature of the air flow, and/or any other user-selectable variable that the system is capable of implementing. Using the control signal 176, the air flow system 150 selectively controls which of the plurality of air vents 162 air is directed to flow through. If the position or occupation of a seat 66, 67, 68, 69 is indicated as having changed by the sensing system 152, the
15 controller 160 automatically updates a status of the seat 66, 67, 68, 69 and issues a new control signal to the air flow apparatus 158 to reflect the change in position or occupation.

The control signals 176 dispatched from the controller 160 may comprise a control
20 signal to alter the temperature of the air flow, to direct air flow to a set of vents only, to operate valves associated with one or more vents to achieve an open, closed, or partially closed position, or to alter a direction of air flow from one or more vents. The valves may be operated according to a status of the vents.

25 So, considering the seating arrangement of Figures 2 to 4, the occupancy sensors 154 which monitor the cabin 50 generate occupancy signals to indicate that both the front right and rear right seats 66, 68 are occupied (and that the front and rear left seats 67, 69 are unoccupied). Configuration sensors 170 indicate that the front left seat 67 is reclined. Orientation sensors 172 indicate that the front right seat 66 is rotated 180
30 degrees from its default position and that the rear right seat 68 is rotated 45 degrees to the right from its default position, while the front and rear left seats 67, 69 are at 0 degrees (i.e. no rotation from default position).

The controller 160 receives these generated signals from the occupancy sensors 154 as inputs, and therefore determines that air conditioning is required for the front and rear right seats 66, 68 because these seats are occupied. Because the orientation of each seat is different, the controller 160 operates the vents above the seats according to the orientation. For example, for the front right seat 66, the controller 160 may decrease air flow through vents that are disposed above the back of the seat, while increasing air flow through vents disposed above the user. For each seat the air flow from vents relating to the seat is therefore controlled in an appropriate manner, taking into consideration the relevant seat configuration, orientation and/or location. In addition user preference data within the user preference module 168 is also taken into consideration in generating the control signal for each seat. The processor 160c 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.

By determining the occupation and position of each seat, the controller 160 is capable of implementing a controlled, targeted air flow within the vehicle cabin 50. The air flow apparatus 158 may be controlled to implement direct air flow onto the user or towards an assumed position of the user determined from the seating position, or may implement a thermal curtain surrounding the user. A 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.

5 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 curtain may cool the inner surface of the sidewall such that it does not feel too hot to a user.

10

In some examples, a plurality of air vents may be incorporated into the lower surface 60 of the vehicle cabin 50, in addition, or as an alternative, to those provided in the upper surface 59. Air vents in the lower surface 60 are configured to direct air upwards, while air vents in the upper surface 59 are configured to direct air
15 downwards. Where air vents are positioned in both the upper and lower surfaces 59, 60 of the vehicle cabin 50, 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 surfaces 59, 60 enhances the formation of a thermal curtain, particularly in examples where the vents in the upper and lower surfaces 59, 60 are vertically
20 aligned.

Air flowing through vents in the upper and lower surfaces 59, 60 may be at different temperatures. For example, air flow through the vents in the upper surface 59 may be at a lower temperature than air flow through the vents in the lower surface 60 of the
25 cabin 50. In this way, hot air in the lower region of the cabin 50, which tends to rise, is replenished by the higher temperature air that is provided through the vents in the lower surface 60. In some examples, a first air flow apparatus is provided to provide air flow through the vents in the upper surface 59 of the cabin 50, and a second air flow apparatus is provided to provide air flow through the vents in the lower surface 60. The
30 first and second air flow apparatuses may provide air flow at different temperatures.

In some examples, air vents provided in one of the upper or lower surface 59, 60 of the cabin 50 may act as air outlets, and air vents in the other surface of the upper and lower surface 59, 60 may act as air inlets. In these examples, the inlets passively or

actively draw air through the cabin 50 from the outlets, leading to an increased air flow through the cabin 50.

5 In some examples, air vents may also be operable as air inlets that passively or actively receive air flow from the cabin 50, depending on the control signal 176 received from the controller 160.

Figure 6 illustrates a plan view of an alternative vehicle cabin 650. In the alternative vehicle cabin 650, in addition to reconfiguration and rotation, each seat 666, 667, 668, 10 669 is capable of having its location changed within the vehicle cabin 650. In other words, the seats are not fixed in a particular location within the vehicle cabin 650, and are movable in the horizontal plane. Lateral movements, perpendicular to direction T, and longitudinal movements, parallel to direction T, may be combined to provide a variety of directional movements for each seat.

15 In Figure 6, the default position of each seat is depicted using a dashed outline. The front right seat 666 is occupied and rotated to face the rear surface 656 of the vehicle cabin 650. The other three seats, the front left 667, rear right 668 and rear left seats 669, are moved relative to their original, default location. Particularly, the rear right 20 seat 668 is moved laterally, the rear left seat 669 is moved longitudinally, and the front left seat 667 is moved both laterally and longitudinally.

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 25 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 to the seat and within a predetermined distance or area around the seat.

30 In an example, the position sensors 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.

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 electric vehicles and engine driven vehicles, as well as hybrid vehicles

5

Figure 7 illustrates a method 700 of operation of the air flow system 150 described above. In the method 700, an occupancy signal is received (step 702) by the controller 160 at an input. The occupancy signal indicates that a user is seated in a seat in the cabin 50. The controller 160 also receives (step 704) a seat signal at an input
10 indicating a seat position. The controller 160 generates (step 706) a control signal 176 based on the received signals. The control signal 176 is used to selectively control (step 708) the air flow using the air flow apparatus 158 to direct it through the air vents 162 as required. The method may comprise a processing step of generating the control signal 176. Generating the control signal may be achieved by accessing the
15 memory store, a database, and/or a look-up table.

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 provided with an air flow system and a seat for a user of the vehicle; the seat
5 being moveable into a plurality of positions; the air flow system comprising:

a plurality of air vents;

an air flow apparatus configured to selectively direct an air flow through each of
10 the plurality of air vents; and

a control system comprising one or more controllers configured to:

receive an occupancy signal indicative that a user is seated in the seat;

receive a seat signal indicative of the position of the seat; and

15 output a control signal to the air flow apparatus to selectively control
which of the plurality of air vents to direct the air flow through in dependence on
the occupancy signal and in dependence on the seat signal.

2. The vehicle system as claimed in claim 1, wherein the seat signal indicative of
20 the position of the seat includes information relating to at least one of the 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.

25 3. The vehicle system as claimed in claim 1 or claim 2, comprising at least one
position sensor configured to provide the seat signal.

4. The vehicle system as claimed in any preceding claim, comprising at least one
air vent configured to direct an airflow downwards.

30

5. The vehicle system as claimed in any preceding claim, comprising at least one
air vent configured to direct an airflow upwards.

6. The vehicle system as claimed in any preceding claim, wherein the vehicle cabin is defined at least in part by an upper cabin surface and a lower cabin surface, wherein at least one of the plurality of air vents are disposed in the upper cabin surface and/or at least one of the plurality of air vents are disposed in the lower cabin surface.

5

7. The vehicle system as claimed in claim 6, comprising a first air flow apparatus configured to direct a first air flow through at least one upper air vent in the upper cabin surface and a second air flow apparatus configured to direct an air flow through at least one lower air vent in the lower cabin surface, the upper and lower air vents being
10 configured to direct airflows towards one another to create a thermal curtain within the vehicle cabin.

8. The vehicle system as claimed in claim 7, wherein the first air flow apparatus is configured to direct an airflow which is at a lower temperature than an airflow directed
15 by the second air flow apparatus.

9. The vehicle system as claimed in claim 7, wherein the first air flow apparatus is configured to direct an airflow which is at a higher temperature than an airflow directed by the second air flow apparatus.

20

10. The vehicle system as claimed in any of claims 7 to 9, wherein the at least one upper air vent and the at least one lower air vent are in vertical alignment with one another.

25 11. The vehicle system as claimed in any preceding claim, wherein the controller is configured to provide a control signal to adjust automatically a status of one or more of the plurality of air vents in response to the seat signal.

12. The vehicle system as claimed in any preceding claim, comprising a user
30 preference module for providing user preference data to the controller, the controller being configured to provide a control signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in dependence on the occupancy signal, on the seat signal, and on the user preference data.

13. The vehicle system as claimed in claim 12, wherein the user preference data includes at least one of a temperature of the air flow and a speed of the air flow.

14. A control system for an air flow system for a vehicle system having a vehicle
5 cabin with a vehicle seat, the vehicle seat being moveable into a plurality of positions, the air flow system having a plurality of air vents and an airflow apparatus configured to selectively direct an airflow through each of the plurality of air vents, the control system comprising one or more controllers configured to:

10 receive an occupancy signal indicative that a user is seated in the seat;

receive a seat signal indicative of the position of the seat; and

15 output a control signal to the air flow apparatus to selectively control which of the plurality of air vents to direct the air flow through in dependence on the occupancy signal and in dependence on the seat signal.

15. The control system according to claim 14, wherein the one or more controllers collectively may comprise:

20 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;

25 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.

16. The control system according to claim 14 or claim 15, wherein the one or more controllers are configured to receive a temperature signal indicative of an air cabin
30 temperature, and output the control signal in dependence on the temperature signal.

17. The control system according to any of claims 14 to 16, 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 signal.

18. A vehicle comprising the vehicle system as claimed in any of claims 1 to 13
5 and/or the controller of any of claims 14 to 17.

19. A method of controlling an air flow system for a vehicle system having a vehicle
cabin comprising a vehicle seat, the vehicle seat being moveable into a plurality of
positions, the air flow system having a plurality of air vents and an airflow apparatus
10 configured to selectively direct an airflow through each of the plurality of air vents, the
method comprising:

receiving an occupancy signal indicative that a user is seated in the seat;

15 receiving a seat signal indicative of the position of the seat;

generating a control signal to the air flow apparatus to selectively control which
of the plurality of air vents to direct the air flow through in dependence on the
occupancy signal and in dependence on the seat signal; and

20 selectively directing an air flow through the air vents according to the control
signal.

20. Computer software that, when executed by one or more processors, causes
25 performance of a method according to claim 19.

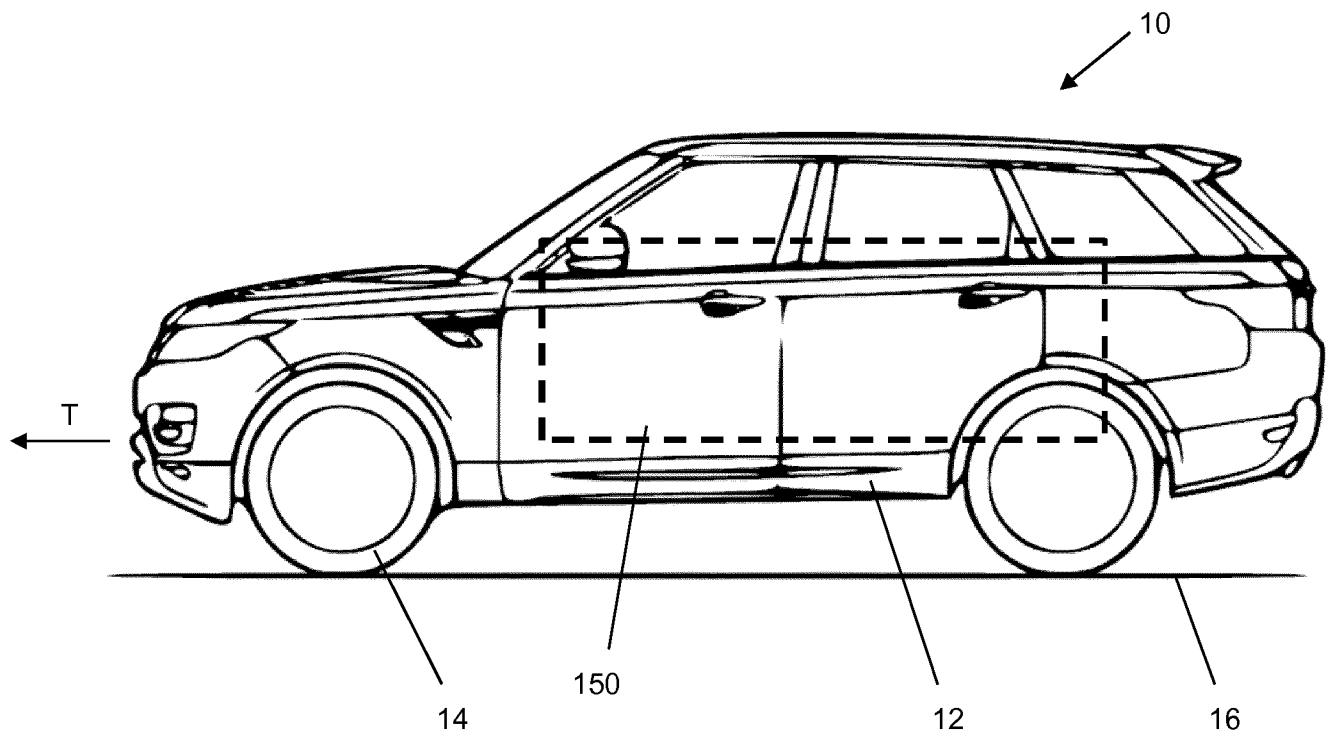


Fig. 1

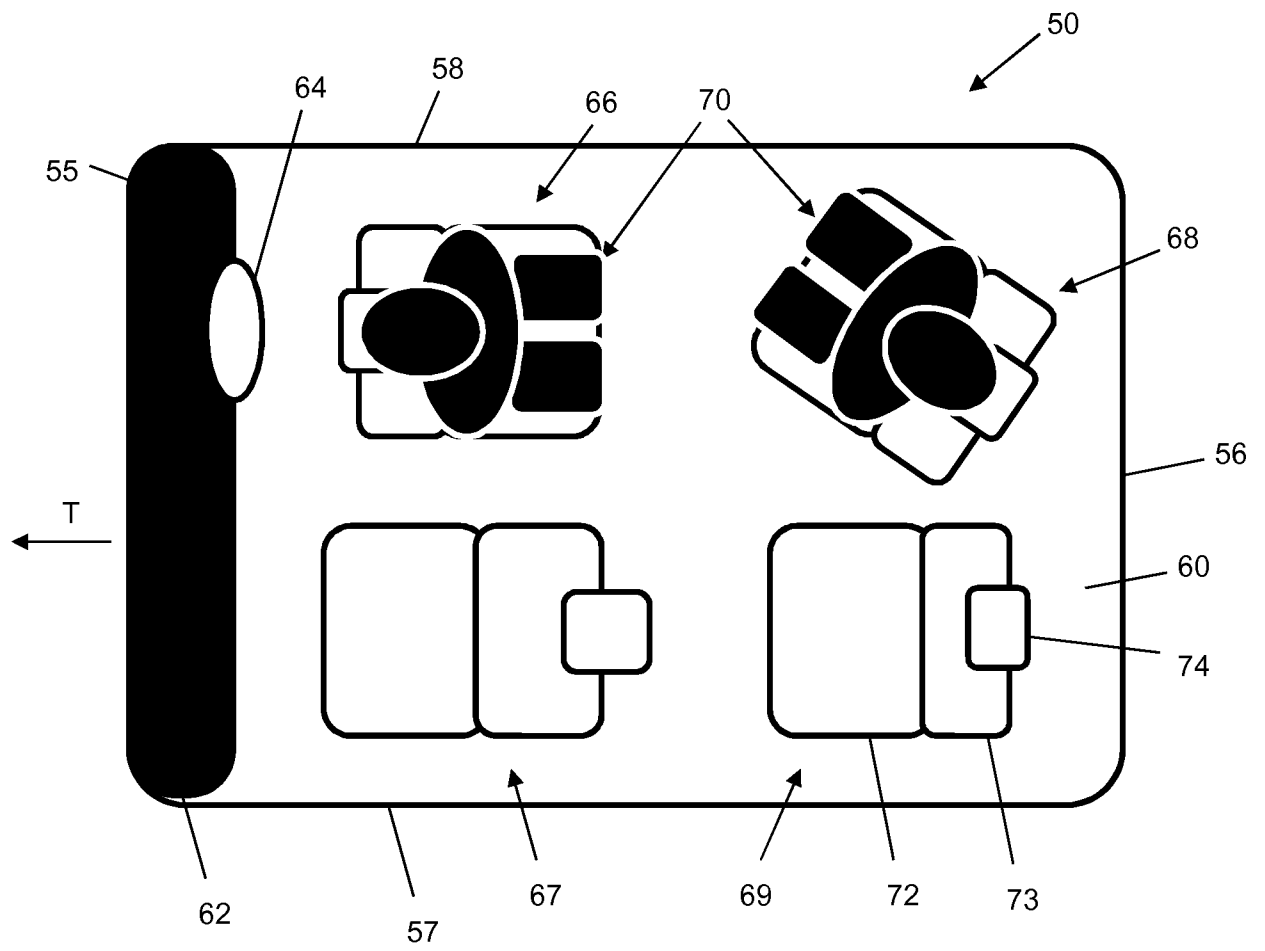


Fig. 2

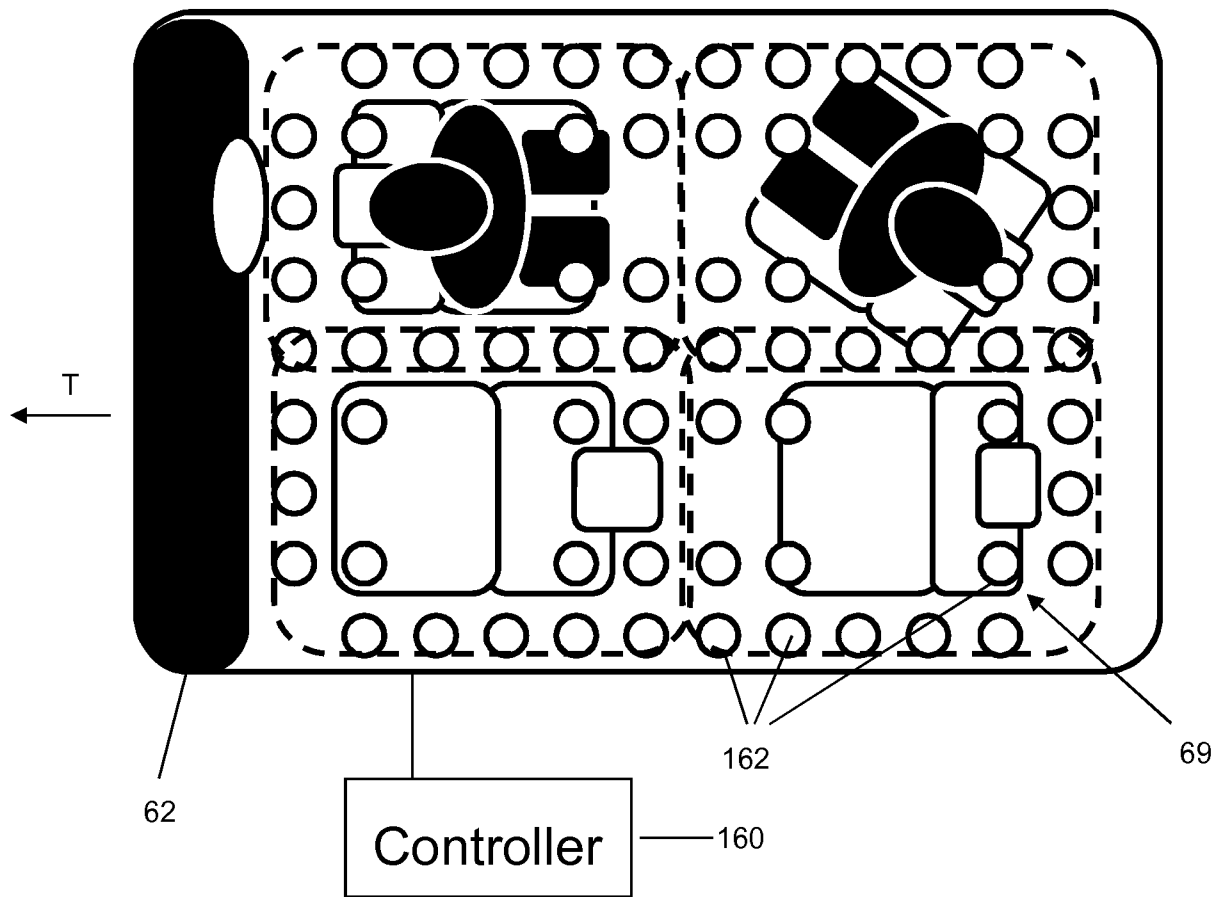


Fig. 3

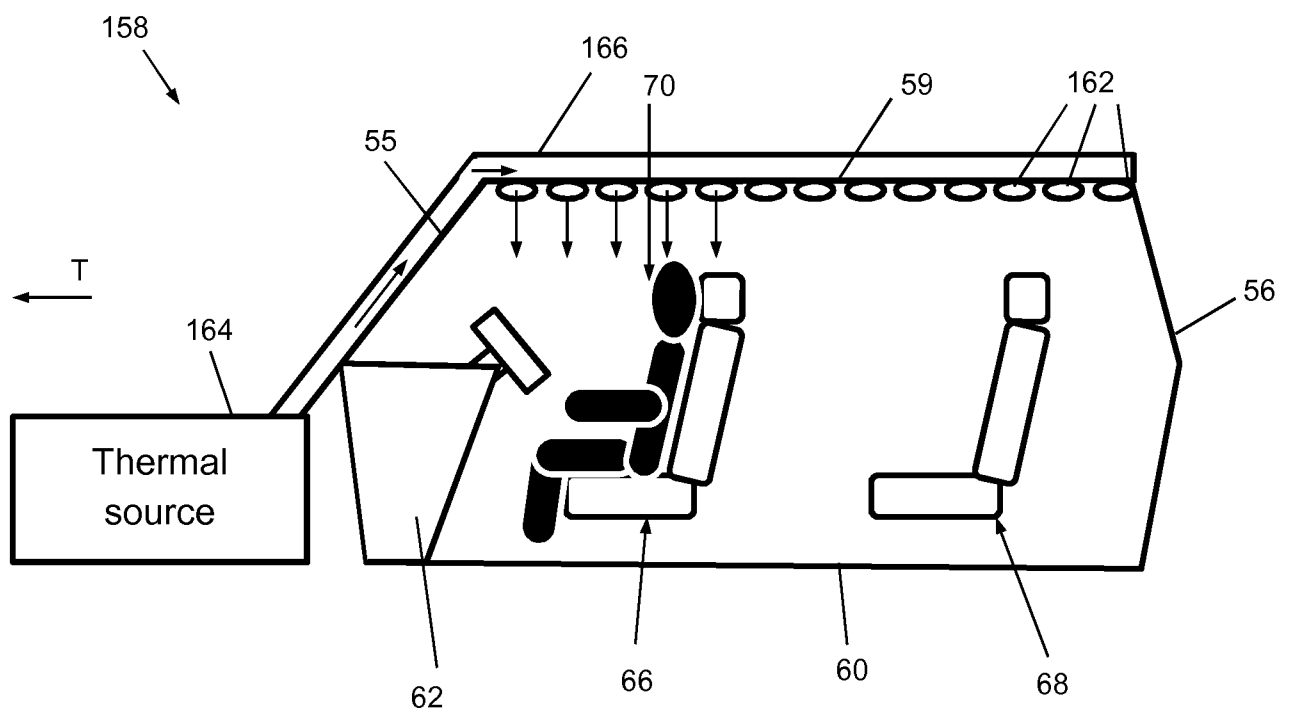


Fig. 4

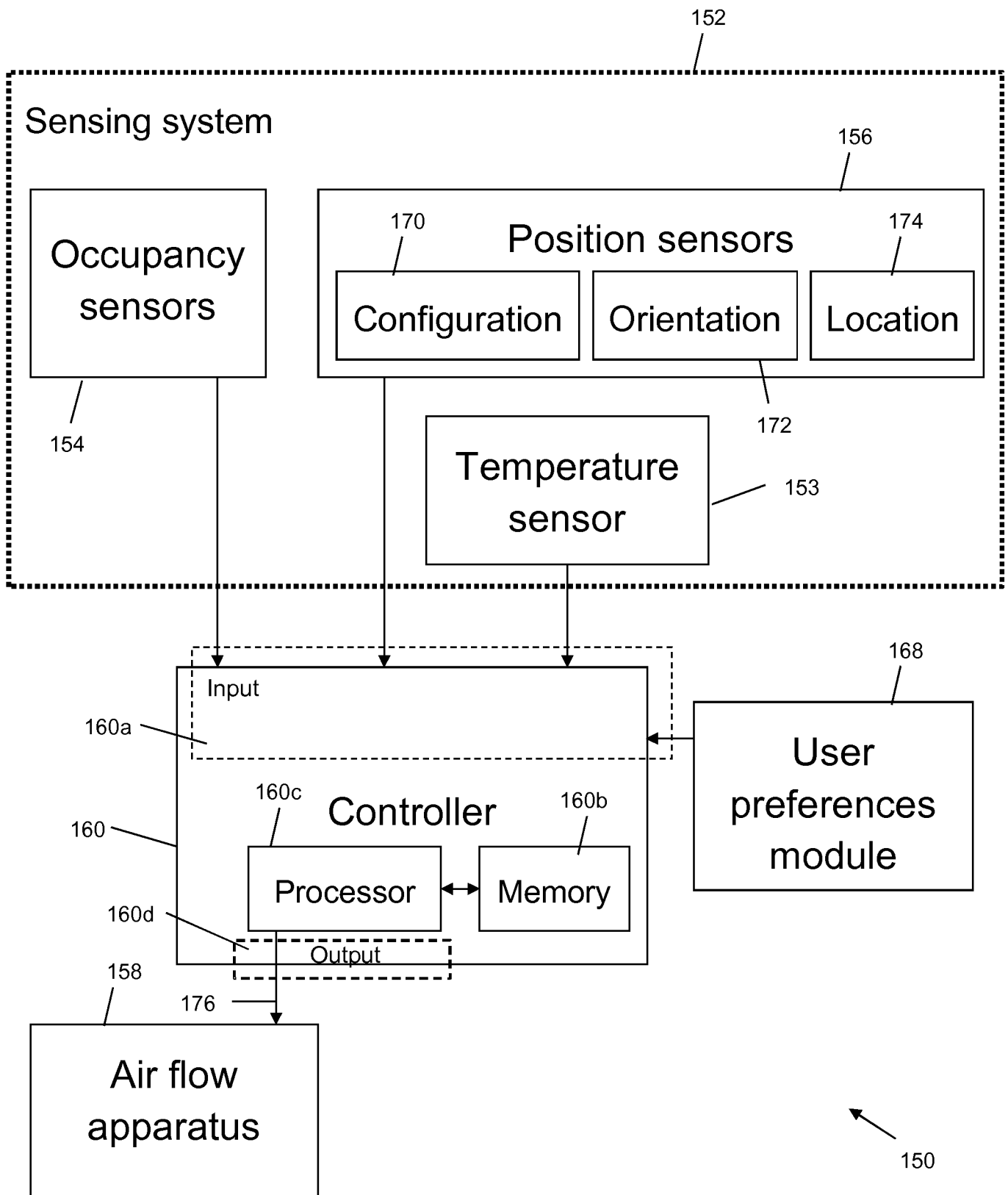


Fig. 5

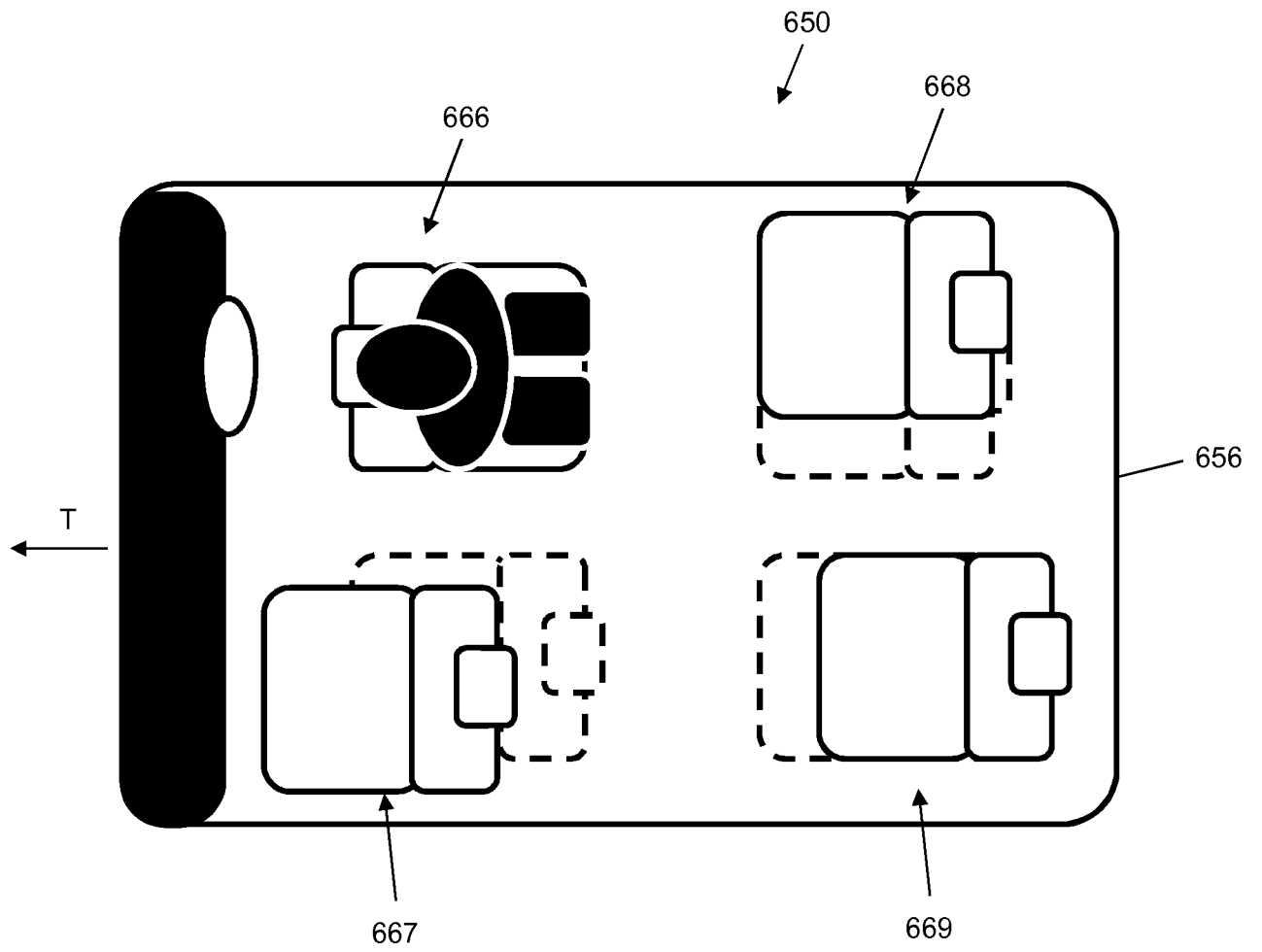


Fig. 6

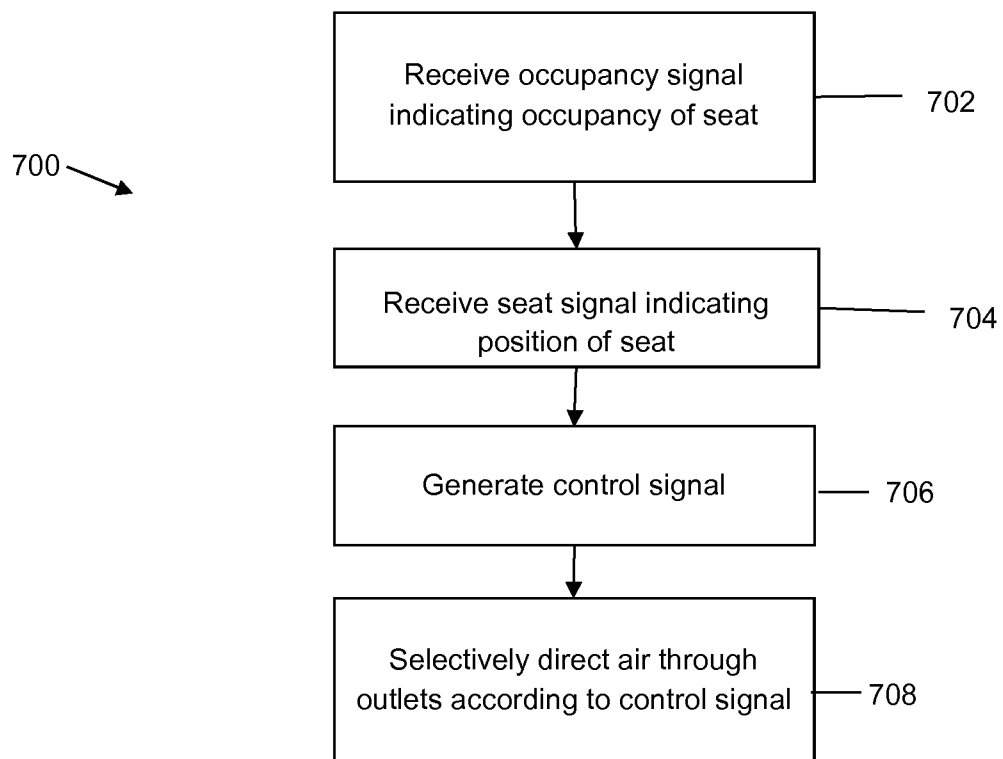


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/078371

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

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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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
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

21 January 2020

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/078371

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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