US 20100009620A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2010/0009620 A1

(43) Pub. Date: Jan. 14, 2010

Kawato et al.

(54) **INSIDE AIR/OUTSIDE AIR SWITCHING DEVICE**

(75) Inventors: **Yoshiaki Kawato**, Anjo-shi (JP); **Donald Federico**, Grass Lake, MI (US)

Correspondence Address:
GIFFORD, KRASS, SPRINKLE,ANDERSON & CITKOWSKI, P.C
PO BOX 7021
TROY, MI 48007-7021 (US)

(73) Assignee: **Toyota Jidosha Kabushiki Kaisha**, Toyota-Shi (JP)

(21) Appl. No.: **12/500,819**

(22) Filed: **Jul. 10, 2009**

(30) **Foreign Application Priority Data**

Jul. 10, 2008 (JP) JP2008-180517

Publication Classification

(51) **Int. Cl.**
F24F 7/00 (2006.01)

(52) **U.S. Cl.** **454/241**

(57) **ABSTRACT**

An inside air/outside air switching device that includes: an inside air/outside air switching case that has an outside air inlet which opens into an engine room, a first inside air inlet and a second inside air inlet which open into a vehicle compartment; an inside air/outside air switching door that is provided in the inside air/outside air switching case, and that switches an open inlet between the first inside air inlet and the outside air inlet; an inside air introduction support door that opens and closes the second inside air inlet; and a noise insulation member that is provided in such a manner that an operation of the inside air introduction support door is not interfered with, and that blocks out noise which is generated in the engine room and which proceeds from the outside air inlet toward the second inside air inlet when the outside air inlet is open.

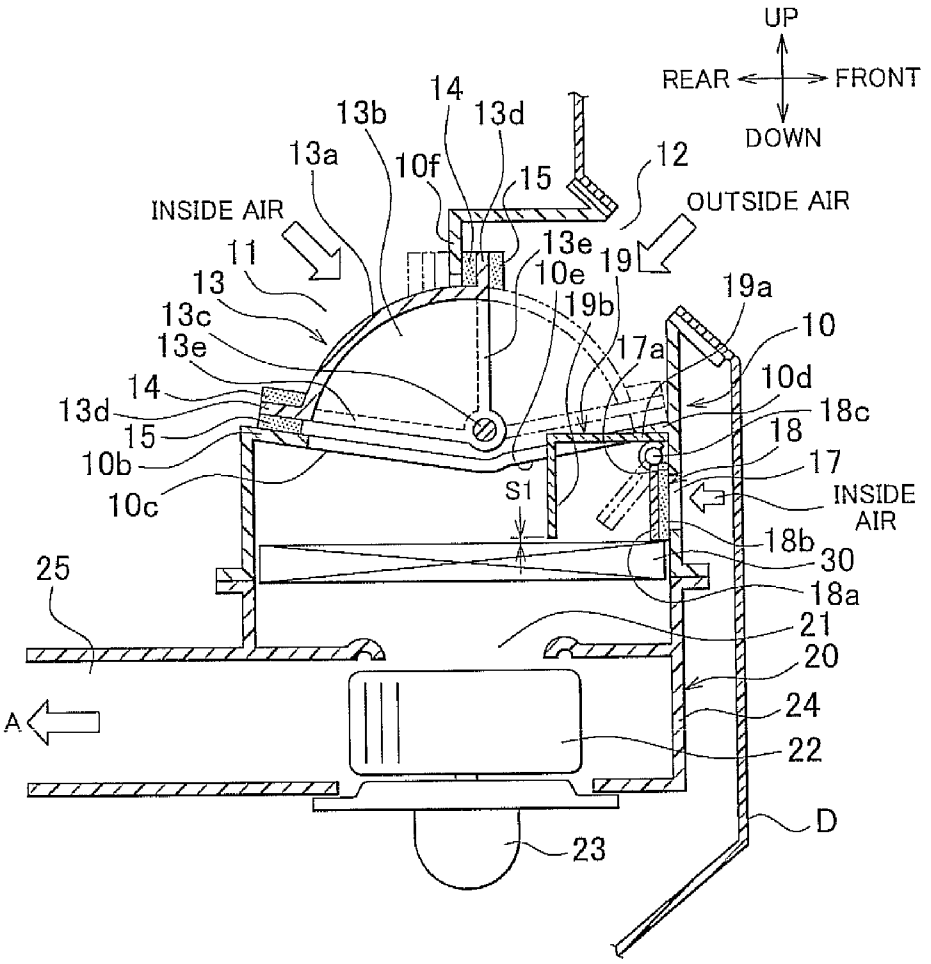


FIG. 1

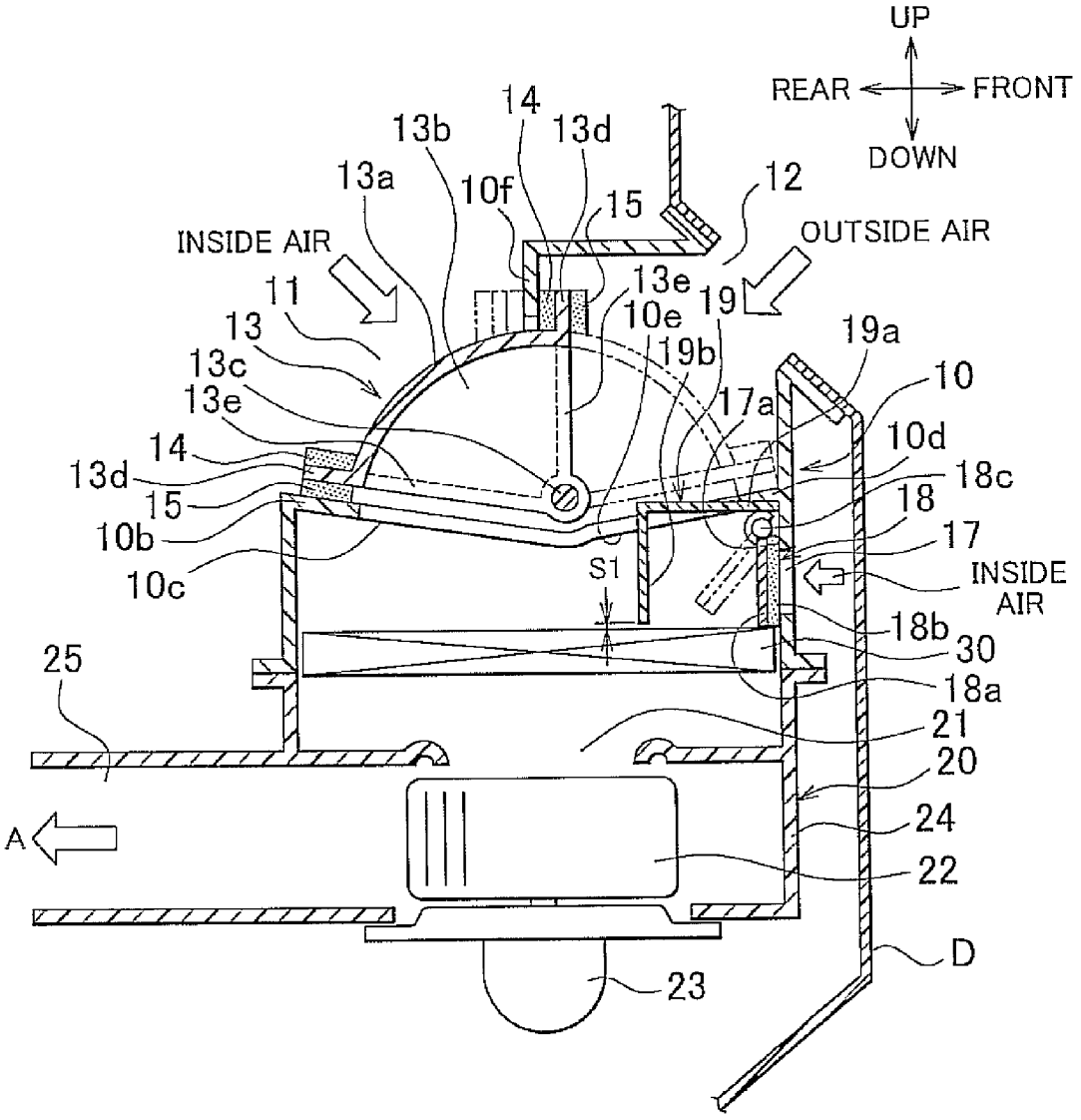

UP
REAR
FRONT
DOWN
INSIDE AIR
OUTSIDE AIR
INSIDE AIR
A
S1
11
12
13
13a
13b
13c
13d
13e
14
15
10
10b
10c
10d
10e
10f
17
17a
18
18b
18c
19
19a
19b
20
21
22
23
24
25
30
D

FIG. 2

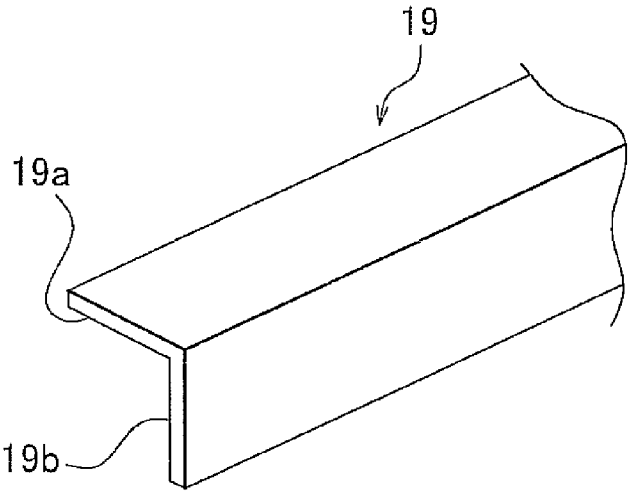

19
19a
19b

FIG. 3

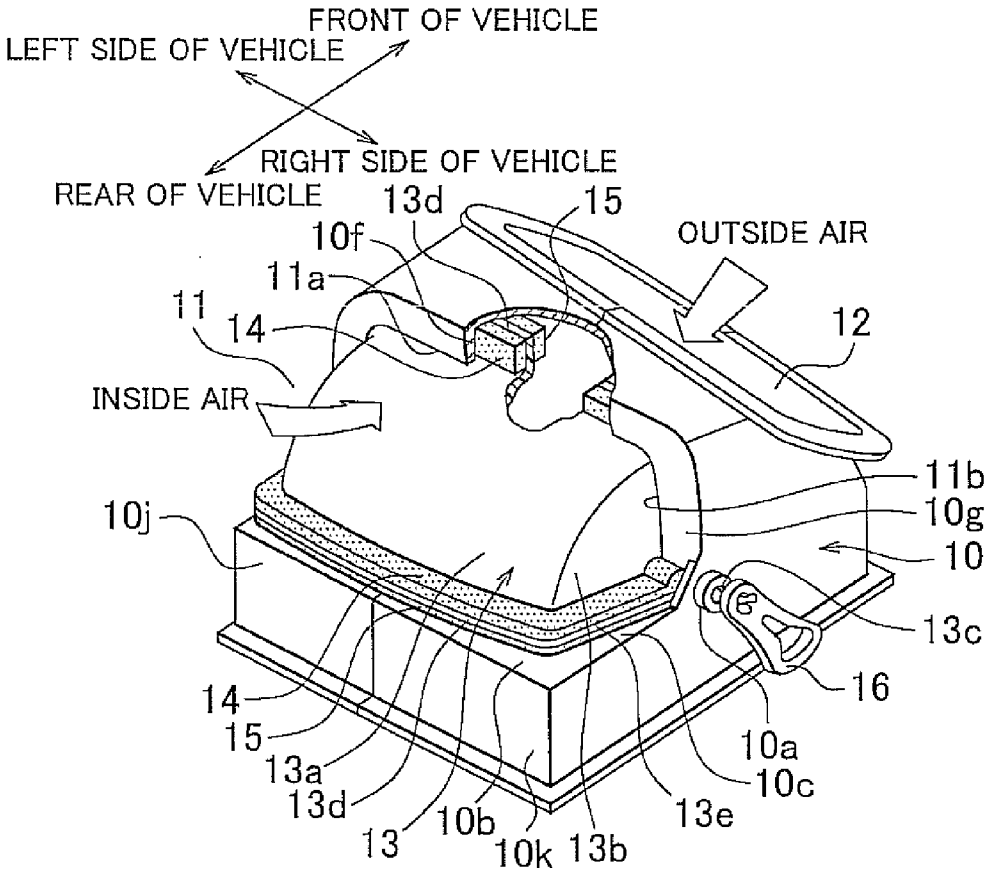

FRONT OF VEHICLE
LEFT SIDE OF VEHICLE
RIGHT SIDE OF VEHICLE
REAR OF VEHICLE
13d
15
10f
11a
11
14
OUTSIDE AIR
12
INSIDE AIR
11b
10g
10j
10
13c
16
14
15
13a
13d
13
10b
10k
13b
13e
10a
10c

FIG. 4

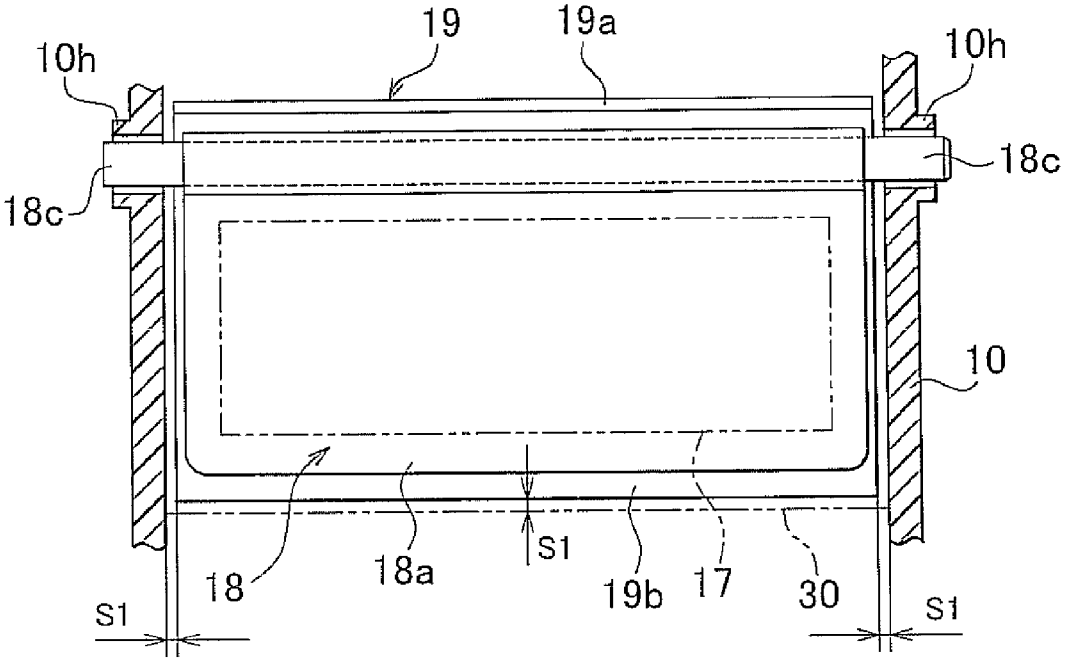

19
19a
10h
10h
18c
18c
10
S1
18
18a
S1
19b
17
30
S1

FIG. 5

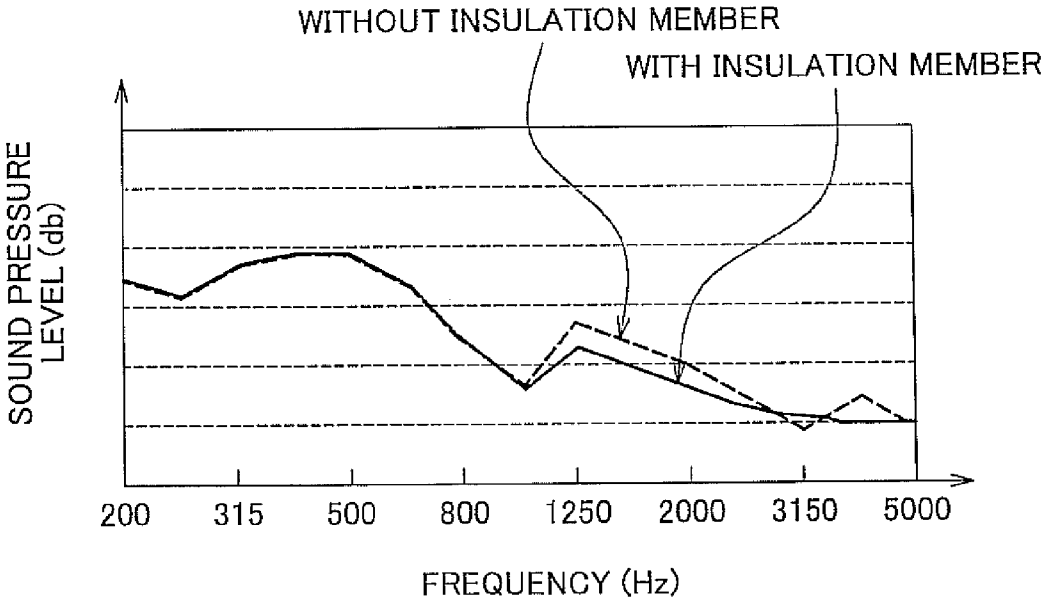

WITHOUT INSULATION MEMBER
WITH INSULATION MEMBER
SOUND PRESSURE LEVEL (db)
200
315
500
800
1250
2000
3150
5000
FREQUENCY (Hz)

FIG. 6

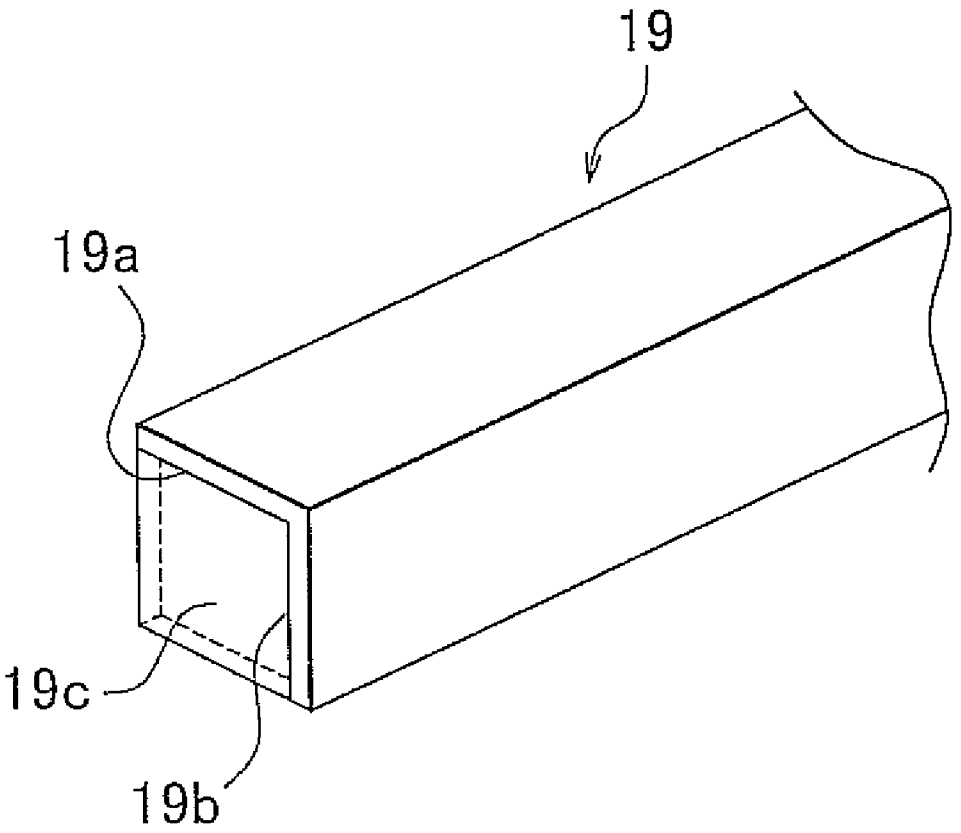


FIG. 7

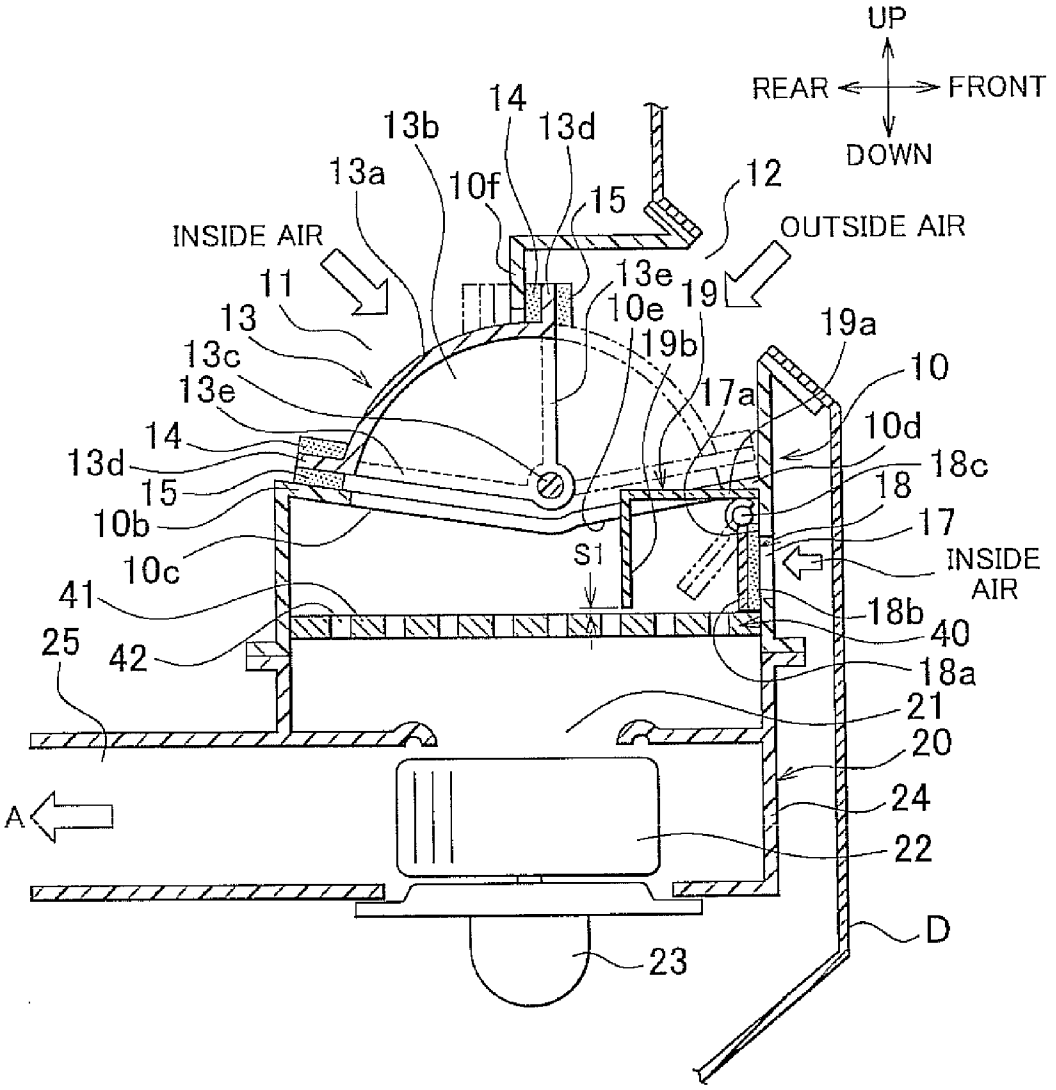
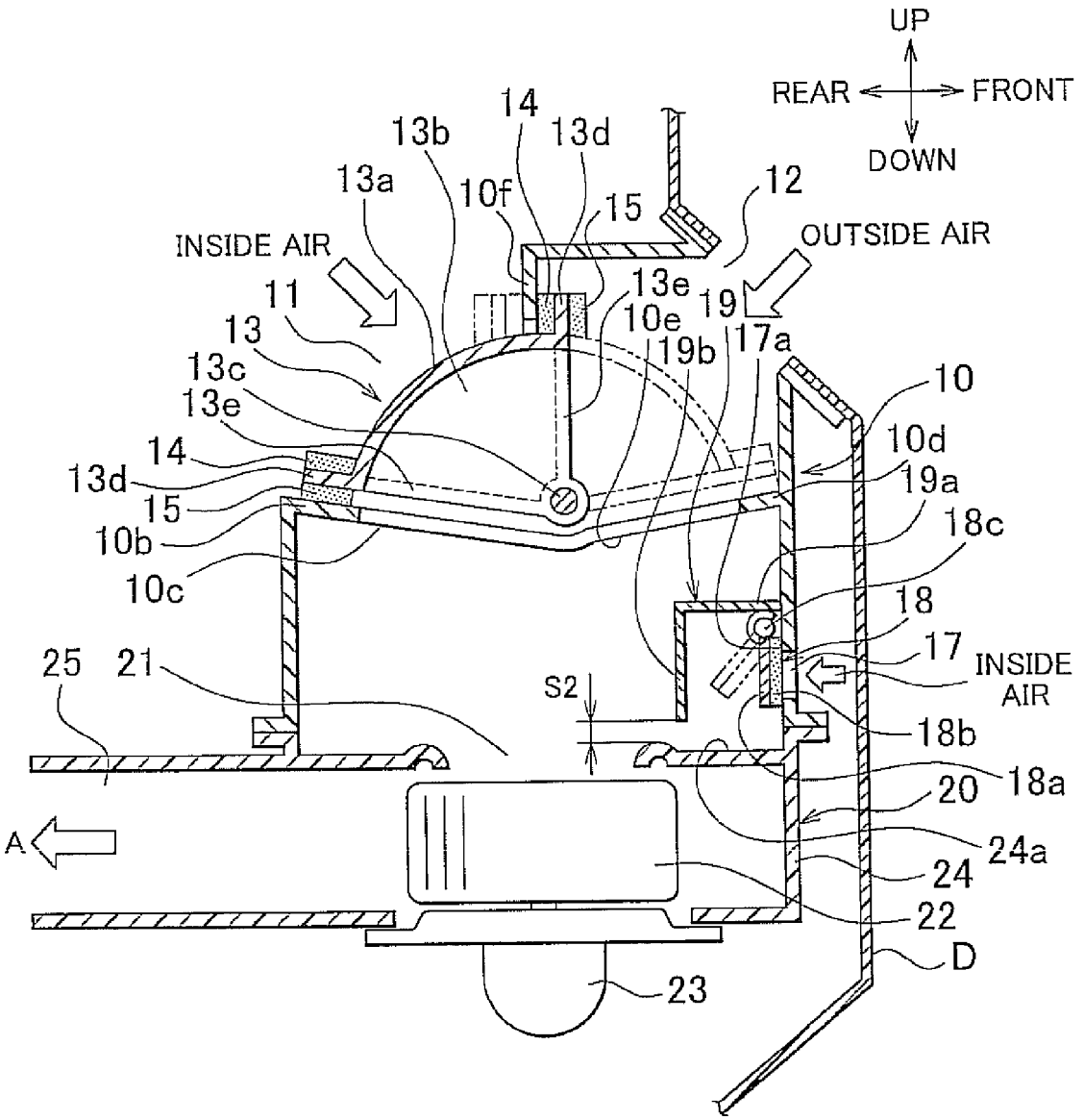

UP
REAR
FRONT
DOWN
INSIDE AIR
OUTSIDE AIR
11
13
13a
13b
13c
13d
13e
14
15
10b
10c
10d
10e
10f
10
12
17
17a
18
18a
18b
18c
19
19a
19b
20
21
22
23
24
25
40
41
42
A
D
S1
INSIDE AIR

FIG. 8


UP
REAR
FRONT
DOWN
INSIDE AIR
OUTSIDE AIR
11
13
13a
13b
13c
13d
13e
14
15
10b
10c
10d
10e
10f
10
19
19a
19b
17
17a
18
18a
18b
18c
20
21
22
23
24
24a
25
S2
A
D

INSIDE AIR/OUTSIDE AIR SWITCHING DEVICE

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2008-180517 filed on Jul. 10, 2008 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates generally to an inside air/outside air switching device that has a first inside air inlet and a second inside air inlet which open into a vehicle compartment, and an outside air inlet which opens into an engine room, and more specifically to a technology for minimizing noise that leaks from the engine room into the vehicle compartment through the second inside air inlet.

[0004] 2. Description of the Related Art

[0005] An inside air/outside air switching device of the above-mentioned type is described in, for example, Japanese Patent Application Publication No. 2002-137621 (JP-A-2002-137621). In the inside air/outside air switching device, a second inside air inlet is formed at a position between an inside air/outside air switching door, which switches an open inlet between a first inside air inlet and an outside air inlet, and an air filter, and an inside air introduction support door that opens and closes the second inside air inlet is provided.

[0006] The inside air introduction support door opens the second inside air inlet when the inside air/outside air switching device is in the outside air introduction mode in which the outside air is drawn into the inside air/outside air switching device through the outside air inlet. Thus, the outside air is introduced into the inside air/outside air switching device through the outside air inlet and part of the inside air is introduced into the inside air/outside air switching device through the second inside air inlet.

[0007] When the inside air/outside air switching device according to JP-A-2002-137621 is in the outside air introduction mode in which the outside air inlet is open, the second inside air inlet is also open. Therefore, engine noise may enter the inside air/outside air switching device through the outside air inlet and then leak into a vehicle compartment through the second inside air inlet.

SUMMARY OF THE INVENTION

[0008] The invention provides an inside air/outside air switching device that has a first inside air inlet, a second inside air inlet, and an outside air inlet, and that is structured in such a manner that noise that leaks into a vehicle compartment through the second inside air inlet is minimized.

[0009] An aspect of the invention relates to an inside air/outside air switching device that includes: an inside air/outside air switching case that has an outside air inlet which opens into an engine room, a first inside air inlet which opens into a vehicle compartment, and a second inside air inlet which opens into the vehicle compartment and which is formed in the side wall of the inside air/outside air switching case; an inside air/outside air switching door that is provided in the inside air/outside air switching case, and that switches an open inlet between the first inside air inlet and the outside air inlet; an inside air introduction support door that opens and closes the second inside air inlet; and a noise insulation member that is provided in such a manner that the noise insulation member does not interfere with the operation of the inside air introduction support door, and that blocks out noise which is generated in the engine room and which proceeds from the outside air inlet toward the second inside air inlet when the outside air inlet is open. The inside air/outside air switching device according the aspect of the invention may further include an air blasting unit that is provided at a position which is downstream of the inside air introduction support door in the direction of air flow, and that takes in the air introduced into the inside air/outside air switching case through the inlets. In the inside air/outside air switching device, the inside air introduction support door may be provided at a position that is downstream of the inside air/outside air switching door in the direction of air flow and that is on the inner side of the second inside air inlet, may move inward from the inner wall face of the inside air/outside air switching case when the inside air introduction support door opens the second inside air inlet, and may open and close the second inside air inlet based on a change in the pressure in the inside air/outside air switching case when the outside air inlet is open, and the noise insulation member may be provided at a position outside but near the operation range of the inside air introduction support door.

[0010] According to the aspect of the invention described above, the noise that is generated in the engine room and enters the inside air/outside air switching case is blocked out by the noise insulation member. With this structure, even if the second inside air inlet is open, the noise that leaks into the vehicle compartment is minimized.

[0011] The inside air/outside air switching device described above may further include an air filter that is provided between the inside air introduction support door and the air blasting unit, and that filters the air introduced into the inside air/outside air switching case through the inlets. The noise insulation member may be formed of two side portions, may have a substantially L-shaped cross section, and may be provided in such a manner that the noise insulation member covers the inside air introduction support door. The inside face of an end of one of the side portions may contact the upper end of the inside air introduction support door. A small space may be left between the lower end of the other side portion and the air filter. In addition, a small space may be left between each of both longitudinal ends of the side portions and the inner wall face of the inside air/outside air switching case.

[0012] The noise that is generated in the engine room and enters the inside air/outside air switching case through the outside air inlet proceeds toward the second inside air inlet through the spaces. However, a labyrinth structure is formed because the spaces are small. Therefore, the noise that leaks into the vehicle compartment through the second inside air inlet is minimized.

[0013] The inside air/outside air switching device described above may further include an air volume adjustment plate that is provided between the inside air introduction support door and the air blasting unit, and that has a blast resistance which is substantially equal to a blast resistance of an air filter that filters the air introduced into the inside air/outside air switching case through the inlets. The noise insulation member may be formed of two side portions, may have a substantially L-shaped cross section, and may be provided in such a manner that the noise insulation member covers the inside air introduction support door. The inside face of an end

of one of the side portions may contact the upper end of the inside air introduction support door. A small space may be left between the lower end of the other side portion and the air volume adjustment plate. In addition, a small space may be left between each of both longitudinal ends of the side portions and the inner wall face of the inside air/outside air switching case.

[0014] The noise that is generated in the engine room and enters the inside air/outside air switching case through the outside air inlet proceeds toward the second inside air inlet through the spaces. However, a labyrinth structure is formed because the spaces are small. Therefore, the noise that leaks into the vehicle compartment through the second inside air inlet is minimized.

[0015] The noise insulation member may be formed of two side portions, may have a substantially L-shaped cross section, and may be provided in such a manner that the noise insulation member covers the inside air introduction support door. The inside face of an end of one of the side portions may contact the upper end of the inside air introduction support door. A space, through which the air that is introduced into the inside air/outside air switching case through the second inside air inlet flows, may be left between the lower end of the other side portion and the upper plate of the air blasting unit.

[0016] With this structure, the noise that is generated in the engine room and enters the inside air/outside air switching device through the outside air inlet is blocked out by the noise insulation member that has the substantially L-shaped cross section. Therefore, the noise that leaks into the vehicle compartment through the second inside air inlet is minimized.

[0017] Side plates may be provided at respective longitudinal ends of the noise insulation member, and each of the side plates may connect one of the side portions to the other side portion. With this structure, the noise that leaks into the vehicle compartment is minimized more reliably because the length of the spaces in the depth direction is increased.

[0018] The pressure in the inside air/outside air switching case when the outside air inlet is open may be determined based on the pressure of the outside air that is introduced into the inside air/outside air switching case through the outside air inlet and the intake negative pressure that is generated when the air blasting unit is driven. When the pressure in the inside air/outside air switching case is lower than the pressure of the inside air, the inside air introduction support door may be drawn inward from the inner wall face to open the second inside air inlet. When the pressure in the inside air/outside air switching case is higher than the pressure of the inside air, the inside air introduction support door may be pushed against the inner wall face of the inside air/outside air switching case to close the second inside air inlet. With this structure, a device that generates power for operating the inside air introduction support door need not be provided, and part of the inside air is introduced into the inside air/outside air switching case through the second inside air inlet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The features, advantages, and technical and industrial significance of this invention will be described in the following detailed description of example embodiments of the invention with reference to the accompanying drawings, in which the same or corresponding portions will be denoted by the same reference numerals, and wherein:

[0020] FIG. **1** is a view schematically showing the overall structure of an inside air/out side air switching device according to a first embodiment of the invention;

[0021] FIG. **2** is a perspective view showing the appearance of a noise insulation member according to the first embodiment of the invention;

[0022] FIG. **3** is a partially-cutout perspective view showing the inside air/outside air switching device according to the first embodiment of the invention;

[0023] FIG. **4** is a front view showing the state in which an inside air introduction support door is fitted;

[0024] FIG. **5** is a graph showing comparison between the noise level when the noise insulation member according to the first embodiment of the invention is provided and the noise level when no noise insulation member is provided;

[0025] FIG. **6** is a perspective view showing the appearance of a noise insulation member according to a second embodiment of the invention;

[0026] FIG. **7** is a view schematically showing the overall structure of an inside air/outside air switching device according to a third embodiment of the invention; and

[0027] FIG. **8**. is a view schematically showing the overall structure of an inside air/outside air switching device according to a fourth embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0028] Hereafter, an inside air/outside air switching device according to a first embodiment of the invention will be described with reference to FIGS. **1** to **5**. FIG. **1** is a view schematically showing the overall structure of the inside air/outside air switching device. FIG. **2** is a perspective view showing the appearance of a noise insulation member. FIG. **3** is a partially-cutout perspective view showing the inside air/outside air switching device. FIG. **4** is a front view showing the state in which an inside air introduction support door is fitted.

[0029] As shown FIGS. **1** to **3**, the inside air/outside air switching device according to the first embodiment of the invention includes an inside air/outside air switching case **10** and an air blasting unit **20**. The inside air/outside air switching device is provided at the front portion of a vehicle compartment of a vehicle. The inside air/outside air switching device is arranged below a dashboard and on the side of a front passenger seat. The inside air/outside air switching case **10** is formed of a case made of synthetic resin, and the air blasting unit **20** is connected to the bottom of the inside air/outside air switching case **10**. The inner space of the inside air/outside air switching case **10** is communicated with a bell-mouthed inlet **21** of the air blasting unit **20**.

[0030] The inside air/outside air switching case **10** has a first inside air inlet **11** and a second inside air inlet **17** (described later in detail) through which the air in the vehicle compartment is introduced into the inside air/outside air switching case **10**, and an outside air inlet **12** through which the air outside the vehicle compartment is introduced into the inside air/outside air switching case **10**. The first inside air inlet **11** and the second inside air inlet **17** open into the vehicle compartment, and the outside air inlet **12** opens into the engine room. The vehicle compartment and the engine room are separated from each other by a dash panel D.

[0031] A rotary door **13**, which is an inside air/outside air switching door that is used to switch the air that is introduced into the inside air/outside air switching case **10** between the

inside air and the outside air, is provided at a position that is downstream of the first inside air inlet **11** and the outside air inlet **12** in the direction of air flow. The rotary door **13** is arranged so as to pivot about right and left pivot shafts **13***c*. The rotary door **13** is formed of a peripheral wall **13***a* having an arc-shaped cross section, and fan-shaped side plates **13***b* that are formed at respective sides of the peripheral wall **13***a*.

[0032] The peripheral wall **13***a* pivots about the pivot shafts **13***c*. End portions of the pivot shafts **13***c* protrude from the right and left side plates **13***b*, respectively, outward in the axial direction of the pivot shafts **13***c*. The right and left pivot shafts **13***c* are rotatably supported by bearing holes **10***a* formed in the inside air/outside air switching case **10** (see FIG. **3**). The pivot shafts **13***c* are allowed to rotate within a range of approximately 70 degrees.

[0033] Flanges **13***d* are formed on the entire ends of the peripheral wall **13***a* and flanges **13***e* are formed on the entire ends of the side plates **13***b*. The flanges **13***d* are formed on the peripheral wall **13***a* at the ends in the circumferential direction of the peripheral wall **13***a*, and project from the ends outward in the radial direction. The flanges **13***e* are formed at both ends of each of the right and left side plates **13***b*, and project from the ends outward in the axial direction of the pivot shafts **13***c*.

[0034] The rotary door **13** may be made of resin, for example, polypropylene, and is easily produced by forming the above-described portions **13***a* to **13***e* integrally with each other. Thin gaskets **14** and **15** are fixed all over the respective faces of the flanges **13***d* and **13***e* with, for example, an adhesive agent. The gaskets **14** and **15** provide airtight sealing when the first inside air inlet **11** or the outside air inlet **12** is closed by the rotary door **13**.

[0035] Thermoplastic elastomer is preferably used as the material for the gaskets **14** and **15**. The thermoplastic elastomer is an elastic body that exhibits rubber elasticity at ordinary temperatures and that softens and exhibits liquidity (thermoplasticity) at high temperatures. Therefore, the thermoplastic elastomer is formed into shapes in a manner similar to a manner in which ordinary thermoplastic resin is formed into shapes. Therefore, the gaskets **14** and **15** may be formed integrally with the rotary door **13**.

[0036] The first inside air inlet **11** has a peripheral portion opening **11***a* that faces the peripheral wall **13***a* of the rotary door **13** and side portion openings **11***b* that extend from the peripheral portion opening ha toward the pivot shafts **13***c*. That is, when the rotary door **13** opens the first inside air inlet **11**, not only a portion that corresponds to the peripheral wall **13***a* of the rotary door **13** but also portions that correspond to the side plates **13***b* of the rotary door **13** are open. In contrast, the outside air inlet **12** is formed only of a peripheral portion opening that faces the peripheral wall **13***a* of the rotary door **13**.

[0037] The up-down direction, the right-left direction, and the front-rear direction shown in FIGS. **1** and **3** show the directions of the inside air/outside air switching device when the inside air/outside air switching device is mounted in the vehicle. The pivot shafts **13***c* for the rotary door **13** are arranged at substantially the center of the inside air/outside air switching case **10** in the front-rear direction and below the inlets **11** and **12**. Sealing faces **10***b* and **10***c* are formed at positions posterior to the pivot shafts **13***c* and sealing faces **10***d* and **10***e* are formed at positions anterior to the pivot shafts **13***c*. The sealing faces **10***b*, **10***c*, **10***d* and **10***e* are inclined downward toward the pivot shafts **13***c*. Sealing faces **10***f* and **10***g* are formed at positions above the pivot shafts **13***c*.

[0038] The sealing faces **10***b* to **10***g* are formed in such a manner that flanges **13***d* and **13***e* contact the sealing faces **10***d*, **10***e*, **10***f* and **10***g* when the rotary door **13** is at a position at which the inside air is introduced into the inside air/outside air switching case **10** (position indicated by two-dot chain lines in FIG. **1**), and the flanges **13***d* and **13***e* contact (are brought into surface contact with) the sealing faces **10***b*, **10***c*, **10***f* and **10***g* when the rotary door **13** is at a position at which the outside air is introduced into the inside air/outside air switching case **10** (position indicated by solid lines in FIG. **1**).

[0039] The inside air/outside air switching case **10** having the above-described structure includes at least two cases **10***j* and **10***k* that are separately formed. The inside air/outside air switching case **10** is formed by arranging the separate cases **10***j* and **10***k* next to each other in the longitudinal direction of the rotary door **13**, that is, the right-left direction of the vehicle and then connecting the cases **10***j* and **10***k* integrally with each other. The sealing faces **10***b* to **10***g* are formed integrally with the inside air/outside air switching case **10**.

[0040] A switching link member **16** made of resin (see FIG. **3**) is connected integrally with one end of the pivot shaft **13***c* of the rotary door **13**. A manual operation force, which is applied to an inside air/outside air switching operation member (e.g. manual operation lever) provided in an air-conditioning operation panel (not shown), is transmitted from the switching link member **16** to the pivot shaft **13***c* via, for example, a cable to cause the rotary door **13** to pivot about the pivot shafts **13***c*.

[0041] Alternatively, an actuator (e.g. motor) may be electrically actuated with the use of an inside air/outside air changeover switch in the air-conditioning operation panel, and the switching link member **16** may be operated by the actuator so that the rotary door **13** pivots about the pivot shafts **13***c*.

[0042] An air filter **30** is provided in the inside air/outside air switching device. In the air filter **30**, a filter member formed of, for example, corrugated Japanese paper or a porous urethane foam is supported by a frame made of resin. The air filter **30** has a flat plate shape as shown in FIG. **1**, and removes dust in the air. When required, the filter member may be provided with an absorbent, for example, activated charcoal, which absorbs malodorous components. In this way, the filter member offers deodorization performance.

[0043] In the inside air/outside air switching case **10**, the air filter **30** is provided at a position downstream of the pivot shafts **13***c* of the rotary door **13** in the direction of air flow so that the air filter **30** does not interfere with the pivot motion of the rotary door **13**. The air blasting unit **20** includes a blast fan **22** formed of a centrifugal multiblade blower, a drive motor **23**, and a casing **24**. The casing **24** is made of resin material, and formed in a scroll shape.

[0044] The blast fan **22** is driven by the motor **23** so that the air taken in the blast fan **22** through the inlet **21** flows outward in the radial direction of the blast fan **22** as indicated by an arrow A. An air outlet **25** of the casing **24** is connected to an air-conditioning duct (not shown). The blast fan **22** and the motor **23** may be included in an air blasting unit according to the invention.

[0045] A heat exchanger for cooling air, a heat exchanger for heating air, etc. are housed in the air-conditioning duct. The air delivered from the air blasting unit **20** is cooled, dehumidified, and re-heated while passing through the air-

conditioning duct. In this way, the temperature of the air is adjusted. Then, the air is introduced into the vehicle compartment.

[0046] The second inside air inlet **17** is formed in the inside air/outside air switching case **10** at a side wall on the vehicle front side. In addition, the second inside air inlet **17** is formed at a position below the outside air inlet **12**. That is, the second inside air inlet **17** is formed at a position between the rotary door **13** and the air filter **30**. An inside air introduction support door **18**, which opens and closes the second inside air inlet **17**, is arranged on the inner side of the second inside air inlet **17**, that is, at a position closer to the rear of the vehicle than the second inside air inlet **17**. The inside air introduction support door **18** is arranged in such a manner that the inside air introduction support door **18** does not interfere with the pivot motion of the rotary door **13**.

[0047] As shown in FIGS. **1** and **4**, the inside air introduction support door **18** includes a door member **18***a*, which is formed of a thin rectangular plate, and a pivot shaft **18***c*. A gasket **18***b* is fitted on a face of the door member **18***a*, which faces the second inside air inlet **17**. The gasket **18***b* provides airtight sealing when the inside air introduction support door **18***a* contacts a sealing face **17***a* (see FIG. **1**) in the side wall, which defines the second inside air inlet **17**. Therefore, for example, porous elastic material, for example, a urethane foam or the above-described thermoplastic elastomer may be used as the material for the gasket **18***b*.

[0048] Both ends of the pivot shaft **18***c* are rotatably supported by bearing holes **10***h* that are formed in the inside air/outside air switching case **10**, at positions above the second inside air inlet **17**. When the operation of the blast fan **22** does not operate, the inside air introduction support door **18** according to the first embodiment of the invention is oriented in the vertical direction (direction of gravitational force) as indicated by solid lines in FIG. **1** so as to close the second inside air inlet **17**.

[0049] The inside air introduction support door **18** opens and closes the second inside air inlet **17** in response to changes in the pressure in the inside air/outside air switching case **10**. In the outside air mode in which the outside air inlet **12** is opened and the first inside air inlet **11** is closed by the rotary door **13**, the pressure in the inside air/outside air switching case **10** is determined based on the pressure of the outside air that is introduced into the inside air/outside air switching case **10** through the outside air inlet **12**, that is, the pressure of the outside air, which is influenced by the dynamic pressure that is generated when the vehicle travels, and the intake negative pressure that is generated when the blast fan **22** is driven.

[0050] More specifically, when the blast fan **22** rotates at a high speed, the intake negative pressure increases and the pressure in the inside air/outside air switching case **10** decreases. When the vehicle travels at a high speed, the dynamic pressure increases and the pressure in the inside air/outside air switching case **10** increases. When the vehicle compartment needs to be warmed up rapidly, for example, when a heater is turned on in winter, the voltage that is supplied to the drive motor **23** is maximized to maximize the rotational speed of the blast fan **22** (to maximize the volume of air delivered from the blast fan **22**). In this way, the maximum heating capacity is utilized. As a result, the pressure in the inside air/outside air switching case **10** falls below the pressure in the vehicle compartment.

[0051] That is, the intake negative pressure is introduced into the area near the inside air introduction support door **18**, which causes a pressure difference between the pressure in the area near the inside air introduction support door **18** and the pressure in the vehicle compartment, that is, the pressure outside the inside air/outside air switching case **10**. Namely, a pressure change is caused in the inside air/outside air switching case **10**. With the use of this pressure difference, the inside air introduction support door **18** pivots inward from the inner wall face of the inside air/outside air switching case **10** as indicated by two dot chains line in FIG. **1**. As a result, the second inside air inlet **17** is opened.

[0052] In other words, when the pressure in the inside air/outside air switching case **10** is lower than the pressure of the inside air, the inside air introduction support door **18** moves away from the second inside air inlet **17** and drawn inward from the inner wall face of the inside air/outside air switching case **10**. As a result, the second inside air inlet **17** is opened. Thus, part of the inside air is drawn into the inside air/outside air switching case **10** through the second inside air inlet **17**. The temperature of the inside air is higher than the low temperature of the outside air in winter. Therefore, if part of the inside air is mixed with the outside air, the temperature of the air at an inlet of the heat exchanger for heating air provided in the air-conditioning duct increases. As a result, the temperature of the air that is warmed while the air passes through the heat exchanger for heating is made higher than that when only the outside air is introduced into the inside air/outside air switching case **10**. As a result, the heating efficiency is enhanced.

[0053] On the other hand, when the pressure in the inside air/outside air switching case **10** is higher than the pressure of the inside air, the inside air introduction support door **18** is pushed against the inner wall face of the inside air/outside air switching case **10**, more specifically, the inner wall face at a portion around the second inside air inlet **17**. As a result, the second inside air inlet **17** is closed. Thus, it is possible to avoid the situation where the low temperature outside air passes through the second inside air inlet **17** and directly flows into the vehicle compartment while the vehicle compartment is heated in the outside air mode.

[0054] The opening amount of the inside air introduction support door **18**, in other words, the volume of inside air that is introduced into the inside air/outside air switching case **10** through the second inside air inlet **17** may be adjusted based on the relationship between the weight (gravity) of the inside air introduction support door **18** and the pressure of the air delivered from the blast fan **22**. Accordingly, the required volume of inside air that is introduced into the inside air/outside air switching case **10** may be ensured by changing the weight of the inside air introduction support door **18**.

[0055] A noise insulation member **19** is provided at a position that is outside but near the operation range of the inside air introduction support door **18**. The noise insulation member **19** blocks out the noise generated in the engine room, which proceeds from the outside air inlet **12** toward the second inside air inlet **17** when the outside air inlet **12** is open.

[0056] As shown in FIGS. **1**, **2** and **4**, the cross section of the noise insulation member **19** is in a substantially L-shape. The noise insulation member **19** is formed of a side portion **19***a* and another side portion **19***b*. The inner side of the end portion of the side portion **19***a* contacts the inside air introduction support door **18** at a portion near the top of the pivot shaft **18***c*, that is, the upper end of the inside air introduction support

door **18**. A small space S**1** is left between the lower end of the side portion **19***b* and the upper face of the air filter **30** (see FIG. **1**).

[0057] The space S**1** left between the upper face of the air filter **30** and the noise insulation member **19** is determined in such a manner that the air filter **30** is attached to and detached from the inside air/outside air switching case **10** without hindrance. In addition, a small space S**1** is left between each of both ends of the noise insulation member **19**, that is, the side portions **19***a* and **19***b*, and the inner wall of the inside air/outside air switching case **10** (see FIG. **4**). That is, the noise insulation member **19** is formed so as to cover the inside air introduction support door **18**. The space S**1** left between the inner wall of the inside air/outside air switching case **10** and the noise insulation member **19** may be smaller than the space between the side portion **19***b* and the upper face of the air filter **30**.

[0058] With this structure, the noise that is generated in the engine room and that enters the inside air/outside air switching case **10** through the outside air inlet **12** is blocked out by the noise insulation member **19**. The noise generated in the engine room leaks toward the second inside air inlet **17** through the small spaces S**1**. However, the noise that leaks toward the second inside air inlet **17** is minimized because a labyrinth structure is formed due to the small spaces S**1**.

[0059] Next, the operation of the inside air/outside air switching device having the above-described structure will be described. The air that is introduced into the inside air/outside air switching case **10** may be switched between the inside air and the outside air by pivoting the rotary door **13** about the pivot shafts **13***c*. To select the outside air introduction mode, the rotary door **13** is pivoted to the position indicated by the solid lines in FIG. **1** (FIG. **3** shows the case where the rotary door **13** is at the position at which the outside air is introduced into the inside air/outside air switching case **10**).

[0060] Thus, the peripheral wall **13***a* of the rotary door **13** closes the peripheral portion opening **11***a* of the first inside air inlet **11**, and the side plates **13***b* of the rotary door **13** close the side portion openings **11***b* of the first inside air inlet **11**. At the same time, the peripheral wall **13***a* of the rotary door **13** moves away from the airflow path on the outside air inlet **12** side. As a result, the outside air inlet **12** is fully open.

[0061] The gaskets **14** and **15** fixed to the flanges **13***d* and **13***e* of the rotary door **13** are pushed against (brought into surface contact with) the sealing faces **10***b*, **10***c*, **10***f* and **10***g* of the inside air/outside air switching case **10**. Therefore, surface-sealing is provided between the entire ends of the rotary door **13** and the inside air/outside air switching case **10**.

[0062] The space on the inner side of the rotary door **13** is entirely communicated with the outside air inlet **12** and a space upstream of the air filter **30** in the direction of air flow. Therefore, the outside air, which is introduced into the inside air/outside air switching case **10** through the outside air inlet **12** when the blast fan **22** is driven, flows through the space on the inner side of the rotary door **13** and uniformly introduced into the air filter **30**.

[0063] Next, the introduced outside air passes through the air filter **30**, and fine dust, malodorous components, etc. are absorbed in the air filter **30** and therefore removed from the air. Then, the introduced outside air from which fine dust, malodorous components, etc. are removed is drawn into the air blasting unit **20** through the inlet **21** and delivered toward the air-conditioning duct under pressure.

[0064] The intake negative pressure is introduced into the area near the air filter **30** and the inside air introduction support door **18** when the blast fan **22** is driven, which causes a pressure difference between the pressure in this area and the pressure in the vehicle compartment, that is, the pressure outside the inside air/outside air switching case **10**. Due to this pressure difference, the inside air introduction support door **18** opens the second inside air inlet **17**. That is, the inside air introduction support door **18** pivots to the position indicated by the two-dot chain lines in FIG. **1**. As a result, the outside air is introduced into the inside air/outside air switching case **10** through the outside air inlet **12** and part of the inside air is introduced into the inside air/outside air switching case **10** through the second inside air inlet **17**.

[0065] To select the inside air introduction mode, the rotary door **13** is pivoted clockwise by approximately 70 degrees from the position indicated by the solid lines in FIG. **1** to the position indicated by the two-dot chain lines in FIG. **1**. Thus, the gaskets **14** and **15** fixed to the flanges **13***d* and **13***e* of the rotary door **13** are pushed against (brought into surface contact with) the sealing faces **10***d*, **10***e*, **10***f* and **10***g* of the inside air/outside air switching case **10**. Therefore, surface-sealing is provided between the entire ends of the rotary door **13** and the inside air/outside air switching case **10**.

[0066] As a result, the outside air inlet **12** is closed and the first inside air inlet **11** is fully open. The inside air, which is introduced into the inside air/outside air switching case **10** through the first inside air inlet **11** when the blast fan **22** is driven, flows through the space on the inner side of the rotary door **13** and is uniformly introduced into the air filter **30**.

[0067] The introduced inside air passes through the air filter **30**, and fine dust, malodorous components, etc. are absorbed in the air filter **30** and therefore removed from the air. Then, the introduced inside air from which fine dust, malodorous components, etc. are removed is drawn into the air blasting unit **20** through the inlet **21** and delivered toward the air-conditioning duct under pressure.

[0068] In the inside air introduction mode as well the intake negative pressure is introduced into the area near the air filter **30** and the inside air introduction support door **18** when the blast fan **22** is driven, which causes a pressure difference between the pressure in the area and the pressure in the vehicle compartment, that is, the pressure outside the inside air/outside air switching case **10**. Due to this pressure difference, the inside air introduction support door **18** pivots to open the second inside air inlet **17**. As a result, the inside air is introduced into the inside air/outside air switching case **10** through the first inside air inlet **11** and part of the inside air is introduced into the inside air/outside air switching case, **10** through the second inside air inlet **17**.

[0069] Next, the noise insulating effect provided by the noise insulation member **19** will be described. FIG. **5** is a graph showing comparison between the noise level when the noise insulation member is provided and the noise level when no noise insulation member is provided. More specifically, FIG. **5** shows the comparison of the above-described noise levels near the ear of an occupant in the front passenger seat in the outside air introduction mode, in the case where the inside air/outside air switching device is mounted in the vehicle. A solid line in FIG. **5** shows the characteristic of the noise level when the noise insulation member **19** is provided at a position that is outside but near the operation range of the inside air introduction support door **18**.

[0070] A dashed line in FIG. **5** shows the characteristic of the noise level when no noise insulation member **19** is provided. The graph shows that provision of the noise insulation member **19** decreases the noise level in the frequency range from approximately 1200 Hz to approximately 2500 Hz.

[0071] When the inside air/outside air switching device having the above-described structure is in the outside air introduction mode, the outside air is introduced into the inside air/outside air switching case **10** through the outside air inlet **12** and part of the inside air is introduced into the inside air/outside air switching case **10** through the second inside air inlet **17**. Therefore, the noise generated in the engine room enters the inside air/outside air switching case **10** through the outside air inlet **12** and proceeds toward the second inside air inlet **17**. However the noise generated in the engine room, which enters the inside air/outside air switching case **10** through the outside air inlet **12**, is blocked out by the noise insulation member **19**.

[0072] The noise generated in the engine room leaks toward the second inside air inlet **17** through the small spaces S**1**. However, the noise that leaks toward the second inside air inlet **17** is minimized because the labyrinth structure is formed due to the small spaces S**1**. Thus, even if the second inside air inlet **17** is open, the noise that leaks into the vehicle compartment is minimized.

[0073] In addition, if the inside air introduction support door **18** is opened with the use of the intake negative pressure that is generated when the blast fan **22** is driven, part of the inside air is introduced into the inside air/outside air switching case **10** through the second inside air inlet **17** not only in the outside air introduction mode but also in the inside air introduction mode. Also, a component used to open and close the inside air introduction support door is, for example, a link member, is no longer necessary, which reduces the component cost.

[0074] Next, a second embodiment of the invention will be described. FIG. **6** is a perspective view showing the appearance of a noise insulation member according to the second embodiment of the invention. As shown in FIG. **6**, the noise insulation member **19** according to the second embodiment of the invention is provided with side plates **19***c* that are arranged at respective longitudinal ends of the noise insulation member **19**, and that connect the side portion **19***a* and the side portion **19***b* to each other. That is, the noise insulation member **19** is provided with side walls formed of the side plates **19***c*.

[0075] With this structure, the length of the space S**1** between the upper face of the air filter **30** and the noise insulation member **19** in the depth direction and the length of the space S**1** between the noise insulation member **19** and the inner wall of the inside air/outside air switching case **10** in the depth direction are increased. Therefore, the noise that is generated in the engine room that enters the inside air/outside air switching case **10** through the outside air inlet **12** is reduced. Thus, it is possible to reduce the noise that leaks into the vehicle compartment through the second inside air inlet **17**.

[0076] Next, a third embodiment of the invention will be described. In the embodiments of the invention described above, the air filter **30** is provided between the inside air introduction support door **18** and the air blasting unit **20**. Instead of the air filter **30**, an air volume adjustment plate **40** may be provided. FIG. **7** is a view schematically showing the overall structure of an inside air/outside air switching device according to the third embodiment of the invention. In the inside air/outside air switching case **10** according to the third embodiment of the invention, the air volume adjustment plate **40** is provided at a position that is downstream of the inside air introduction support door **18** in the direction of air flow, as shown in FIG. **7**.

[0077] The air volume adjustment plate **40** is used as a substitute for the air filter **30** after the air filter **30** is removed from the inside air/outside air switching case **10**. The air volume adjustment plate **40** is a pressure loss adjustment plate that is used to adjust the volume of the intake air that is introduced through the inlets **11**, **12** and **17**. In the third embodiment of the invention, the air volume adjustment plate **40** has a draft resistance that is substantially equal to the draft resistance of the air filter **30**. That is, the air volume adjustment plate **40** is formed in such a manner that the draft resistance thereof is substantially equal to the draft resistance of the air filter **30**.

[0078] Therefore, the air volume adjustment plate **40** is formed in such a manner that the air volume adjustment plate **40** is easily attached to and detached from the inside air/outside air switching case **10** as in the case of the air filter **30**, and is formed of a porous plate **41** that has a large number of draft holes **42**. Accordingly, if the air volume adjustment plate **40** is arranged in place of the air filter **30** after the air filter **40** is removed, the volume of the air that passes through the air volume adjustment plate **40** is adjusted in a manner substantially same as that when the air filter **30** is arranged.

[0079] As in the embodiments of the invention described above, the noise insulation member **19** is arranged in such a manner that the inner side of the end portion of the side portion **19***a* contacts the inside air introduction support door **18** at a portion near the top of the pivot shaft **18***c*, that is, the upper end of the inside air introduction support door **18**. A small space S**1** is left between the lower end of the side portion **19***b* and the upper face of the air volume adjustment plate **40** (see FIG. **7**).

[0080] The amount of space S**1** left between the upper face of the air volume adjustment plate **40** and the noise insulation member **19** is determined in such a manner that the air volume adjustment plate **40** is attached to and detached from the inside air/outside air switching case **10** without hindrance. Thus, the noise that is generated in the engine room that enters the inside air/outside air switching case **10** through the outside air inlet **12** is blocked out by the noise insulation member **19**. A small space S**1** is left between each of the both ends of the noise insulation member **19**, that is, the side portions **19***a* and **19***b*, and the inner wall of the inside air/outside air switching case **10** (see FIG. **4**), as in the above-described embodiments.

[0081] A fourth embodiment of the invention will be described. In the embodiments of the invention described above, the air filter **30** or the air volume adjustment plate **40** is arranged between the inside air introduction support door **18** and the air blasting unit **20**. However, the inside air/outside air switching case **10** that includes neither the air filter **30** nor the air volume adjustment plate **40** may be used. FIG. **8** is a view schematically showing the overall structure of the inside air/outside air switching device according to the fourth embodiment of the invention.

[0082] As shown in FIG. **8**, the air blasting unit **20** is provided at a position that is directly downstream of the inside air introduction support door **18** in the direction of air flow. For example, the inside air/outside air switching case **10** accord-

ing to the fourth embodiment of the invention is used when the air filter **30** is provided in the air-conditioning duct (not shown) connected to a downstream-side portion of the air blasting unit **20**.

[0083] Accordingly, a space S**2** is left between the lower end of the side portion **19***b* of the noise insulation member **19** according to the fourth embodiment of the invention and an upper plate **24***a* of the casing **24** of the air blasting unit **20**. The space S**2** is larger than the small space S**1**.

[0084] The space S**2** according to the fourth embodiment of the invention is set in such a manner that the intake air introduced into the inside air/outside air switching case **10** through the second inside air inlet **17** flows toward the inlet **21** of the casing **24**. Therefore, when the second inside air inlet **17** is opened in response of a change in the pressure in the inside air/outside air switching case **10**, the intake air introduced into the inside air/outside air switching case **10** through the second inside air inlet **11** is drawn by the blast fan **22**.

[0085] With the inside air/outside air switching device having the structure described above, the noise that is generated in the engine room that enters the inside air/outside air switching case **10** through the outside air inlet **12** is blocked out by the noise insulation member **19** that has the substantially L-shaped cross section. Accordingly, it is possible to reduce the noise that leaks into the vehicle compartment through the second inside air inlet **17**.

[0086] In the embodiments of the invention described above, the noise insulation member **19** is larger than the inside air introduction support door **18** when viewed in the front-rear direction of the vehicle. Alternatively, the noise insulation member **19** may be equal to or smaller than the inside air introduction support door **18** when viewed in the front-rear direction of the vehicle.

[0087] In the embodiments of the invention described above, the inside air introduction support door **18** is formed by forming the door member **18***a* and the pivot shaft **18***c* integrally with each other and fitting the gasket **18***b* to the door member **18***a*. Alternatively, the inside air introduction support door **18** may be formed by forming material, for example, thermoplastic elastomer, in an elastically deformable sheet shaped plate door.

[0088] More specifically, a plate door is formed of a single sheet, and only one face of an upper portion of the sheet is fixed to an upper portion of the inner wall face around the second inside air inlet **17**. Thus, the second inside air inlet **17** may be opened and closed in response to a change in the pressure in the inside air/outside air switching case **10**.

[0089] In the embodiments of the invention described above, the inside air introduction support door **18** may be opened and closed based on an intake negative pressure generated by the blast fan **22**. Alternatively, the inside air introduction support door **18** may be opened and closed by an actuator, for example, a servo motor.

[0090] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the example embodiments or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the example embodiments are shown in various combinations and configurations, which are example, other combinations and configurations, including more, less or only a single element, are also within the scope of the invention.

What is claimed is:

1. An inside air/outside air switching device, comprising:

an inside air/outside air switching case that has an outside air inlet which opens into an engine room, a first inside air inlet which opens into a vehicle compartment, and a second inside air inlet which opens into the vehicle compartment and which is formed in a side wall of the inside air/outside air switching case;

an inside air/outside air switching door that is provided in the inside air/outside air switching case, and that switches an open inlet between the first inside air inlet and the outside air inlet;

an inside air introduction support door that opens and closes the second inside air inlet; and

a noise insulation member that is provided in such a manner that the noise insulation member does not interfere with an operation of the inside air introduction support door, and that blocks out noise which is generated in the engine room and which proceeds from the outside air inlet toward the second inside air inlet when the outside air inlet is open.

2. The inside air/outside air switching device according to claim **1**, further comprising

an air blasting unit that is provided at a position which is downstream of the inside air introduction support door in a direction of air flow, and that takes in air introduced into the inside air/outside air switching case through the inlets, wherein:

the inside air introduction support door is provided at a position that is downstream of the inside air/outside air switching door in the direction of air flow and that is on an inner side of the second inside air inlet, moves inward from an inner wall face of the inside air/outside air switching case when the inside air introduction support door opens the second inside air inlet, and opens and closes the second inside air inlet based on a change in a pressure in the inside air/outside air switching case when the outside air inlet is open; and

the noise insulation member is provided at a position outside but near an operation range of the inside air introduction support door.

3. The inside air/outside air switching device according to claim **2**, wherein:

the pressure in the inside air/outside air switching case when the outside air inlet is open is determined based on a pressure of outside air that is introduced into the inside air/outside air switching case through the outside air inlet and an intake negative pressure that is generated when the air blasting unit is driven;

when the pressure in the inside air/outside air switching case is lower than a pressure of inside air, the inside air introduction support door is drawn inward from the inner wall face to open the second inside air inlet; and

when the pressure in the inside air/outside air switching case is higher than the pressure of the inside air, the inside air introduction support door is pushed against the inner wall face of the inside air/outside air switching case to close the second inside air inlet.

4. The inside air/outside air switching device according to claim **2**, wherein:

the noise insulation member is provided in such a manner that the noise insulation member covers the inside air introduction support door;

a space, through which the air that is introduced into the inside air/outside air switching case through the second

inside air inlet flows, is left between a downstream-side end of the noise insulation member and an upper plate of the air blasting unit; and

an end of the noise insulation member, which is on an opposite side of the downstream-side end, contacts the inner wall face of the inside air/outside air switching case.

5. The inside air/outside air switching device according to claim **4**, wherein:

the noise insulation member is formed of two side portions, and has a substantially L-shaped cross section; and

an inside face of an end of one of the side portions, which is the end on the opposite side of the downstream-side end of the noise insulation member, contacts an upper end of the inside air introduction support door.

6. The inside air/outside air switching device according to claim **5**, wherein:

side plates are provided at respective longitudinal ends of the noise insulation member; and

each of the side plates connects one of the side portions to the other side portion.

7. The inside air/outside air switching device according to claim **2**, further comprising

an air filter that is provided between the inside air introduction support door and the air blasting unit, and that filters the air introduced into the inside air/outside air switching case through the inlets, wherein:

the noise insulation member is provided in such a manner that the noise insulation member covers the inside air introduction support door;

a small space is left between a downstream-side end of the noise insulation member and the air filter;

an end of the noise insulation member, which is on an opposite side of the downstream-side end, contacts the inner wall face of the inside air/outside air switching case; and

a small space is left between each of both longitudinal ends of the noise insulation member and the inner wall face of the inside air/outside air switching case.

8. The inside air/outside air switching device according to claim **7**, wherein:

the noise insulation member is formed of two side portions, and has a substantially L-shaped cross section; and

an inside face of an end of one of the side portions, which is the end on the opposite side of the downstream-side end of the noise insulation member, contacts an upper end of the inside air introduction support door.

9. The inside air/outside air switching device according to claim **8**, wherein:

side plates are formed at respective longitudinal ends of the noise insulation member; and

each of the side plates connects one of the side portions to the other side portion.

10. The inside air/outside air switching device according to claim **2**, further comprising

an air volume adjustment plate that is provided at a position which is downstream of the inside air introduction support door in the direction of air flow, and that has a draft resistance which is substantially equal to a draft resistance of an air filter that filters the air introduced into the inside air/outside air switching case through the inlets, wherein:

the noise insulation member is provided in such a manner that the noise insulation member covers the inside air introduction support door;

a small space is left between a downstream-side end of the noise insulation member and the air volume adjustment plate;

an end of the noise insulation member, which is on an opposite side of the downstream-side end, contacts the inner wall face of the inside air/outside air switching case; and

a small space is left between each of both longitudinal ends of the noise insulation member and the inner wall face of the inside air/outside air switching case.

11. The inside air/outside air switching device according to claim **10**, wherein:

the noise insulation member is formed of two side portions, and has a substantially L-shaped cross section; and

an inside face of an end of one of the side portions, which is the end on the opposite side of the downstream-side end of the noise insulation member, contacts an upper end of the inside air introduction support door.

12. The inside-air/outside air switching device according to claim **11**, wherein:

side plates are formed at respective longitudinal ends of the noise insulation member; and

each of the side plates connects one of the side portions to the other side portion.

13. The inside air/outside air switching device according to claim **1**, further comprising:

a servo motor that opens and closes the inside air introduction support door.

* * * * *