US 20130043003A1

(19) **United States**

(12) **Patent Application Publication**

TAKAMORI

(10) **Pub. No.: US 2013/0043003 A1**

(43) **Pub. Date: Feb. 21, 2013**

(54) **INDOOR UNIT FOR AIR-CONDITIONING APPARATUS AND AIR-CONDITIONING APPARATUS INCLUDING THE INDOOR UNIT**

(75) Inventor: **Akira TAKAMORI**, Tokyo (JP)

(73) Assignee: **Mitsubishi Electric Corporation**, Tokyo (JP)

(21) Appl. No.: **13/556,252**

(22) Filed: **Jul. 24, 2012**

(30) **Foreign Application Priority Data**

Aug. 18, 2011 (JP) 2011-179180

Publication Classification

(51) **Int. Cl.**
F28F 27/00 (2006.01)

(52) **U.S. Cl.** **165/96**

(57) **ABSTRACT**

An indoor unit for air-conditioning that may suppress the discharge of dewdrops into a conditioned space. An indoor unit including a casing having an air inlet in an upper portion thereof and an air outlet in a lower portion of a front face thereof, a fan, a heat exchange, and a louver configured to redirect air blown out of the air outlet in a vertical direction. The louver includes a main louver and a sub-louver. In a state where the main louver is level, the sub-louver is provided below the main louver. A leeward end of the sub-louver is positioned forward by a first predetermined distance with respect to a virtual perpendicular line passing through a windward end of the main louver. A windward end of the sub-louver is positioned rearward by a second predetermined distance with respect to the virtual perpendicular line.

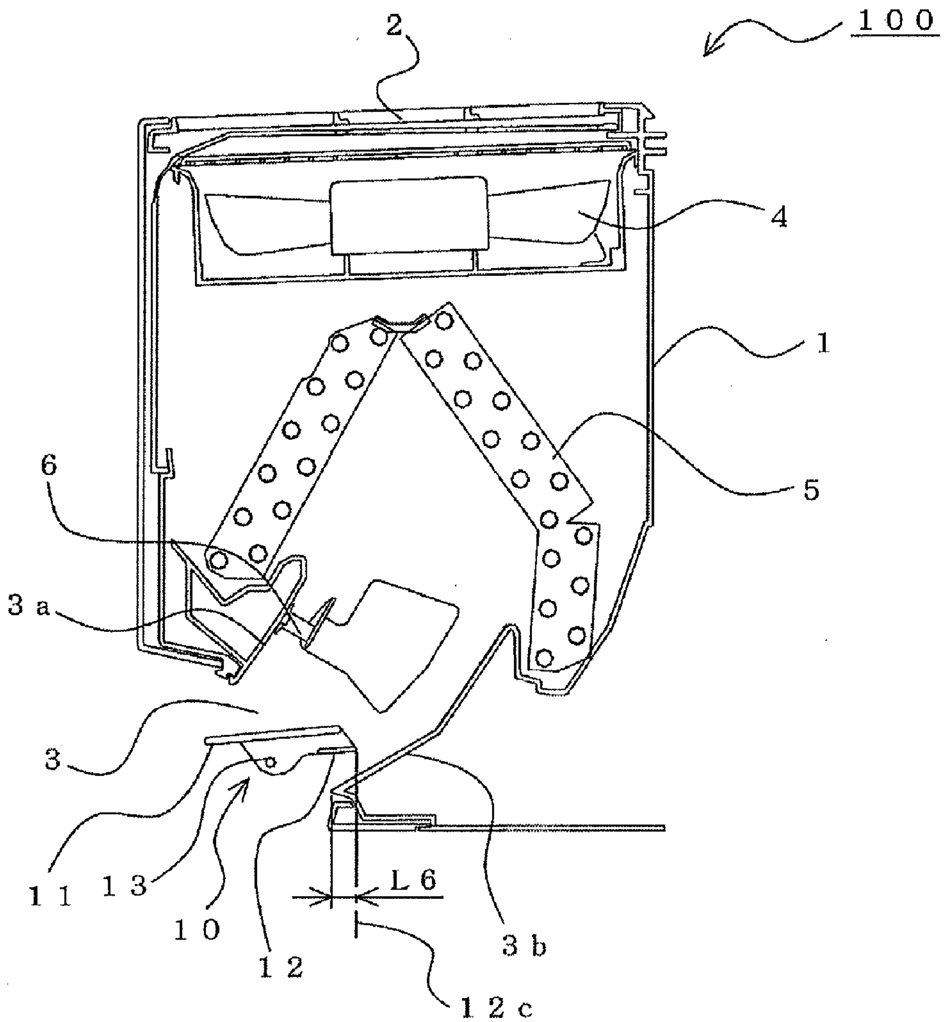


FIG. 1

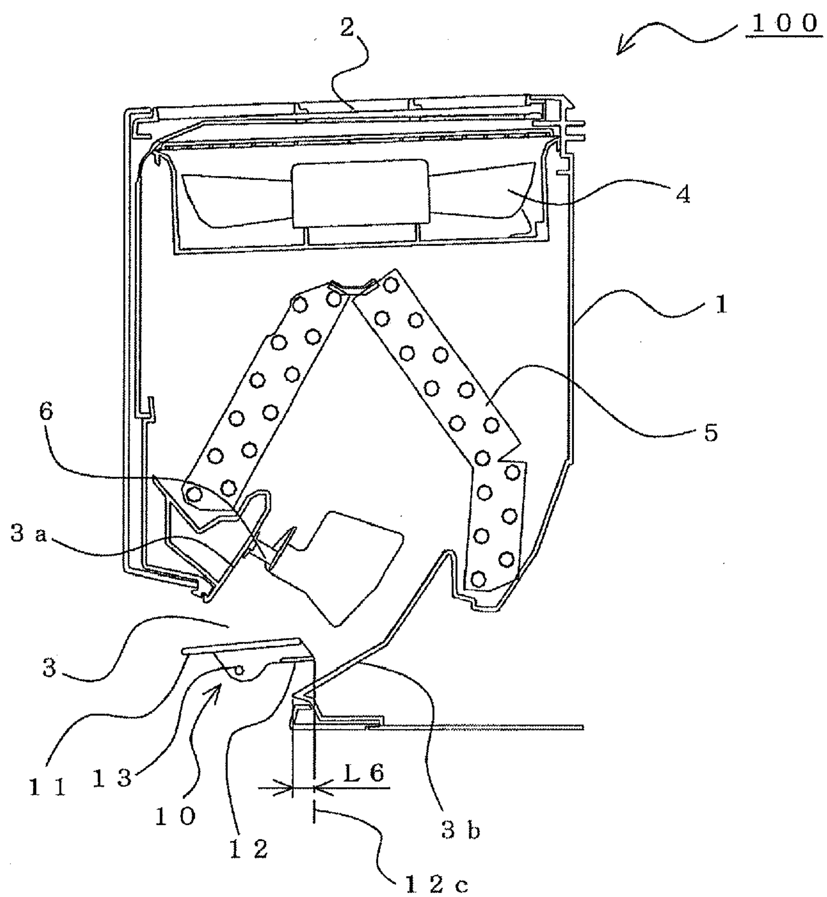


FIG. 2

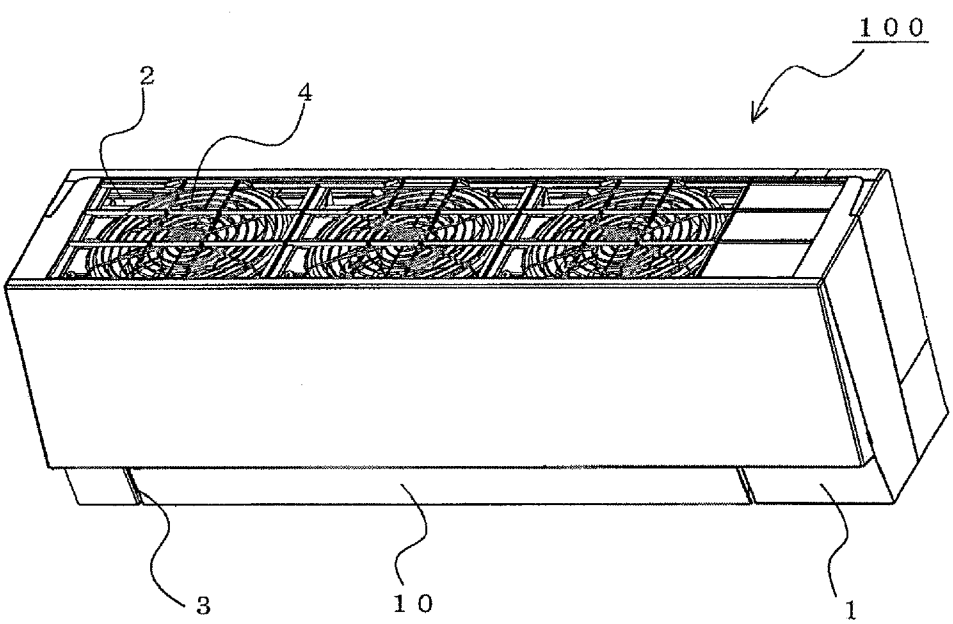


FIG. 3

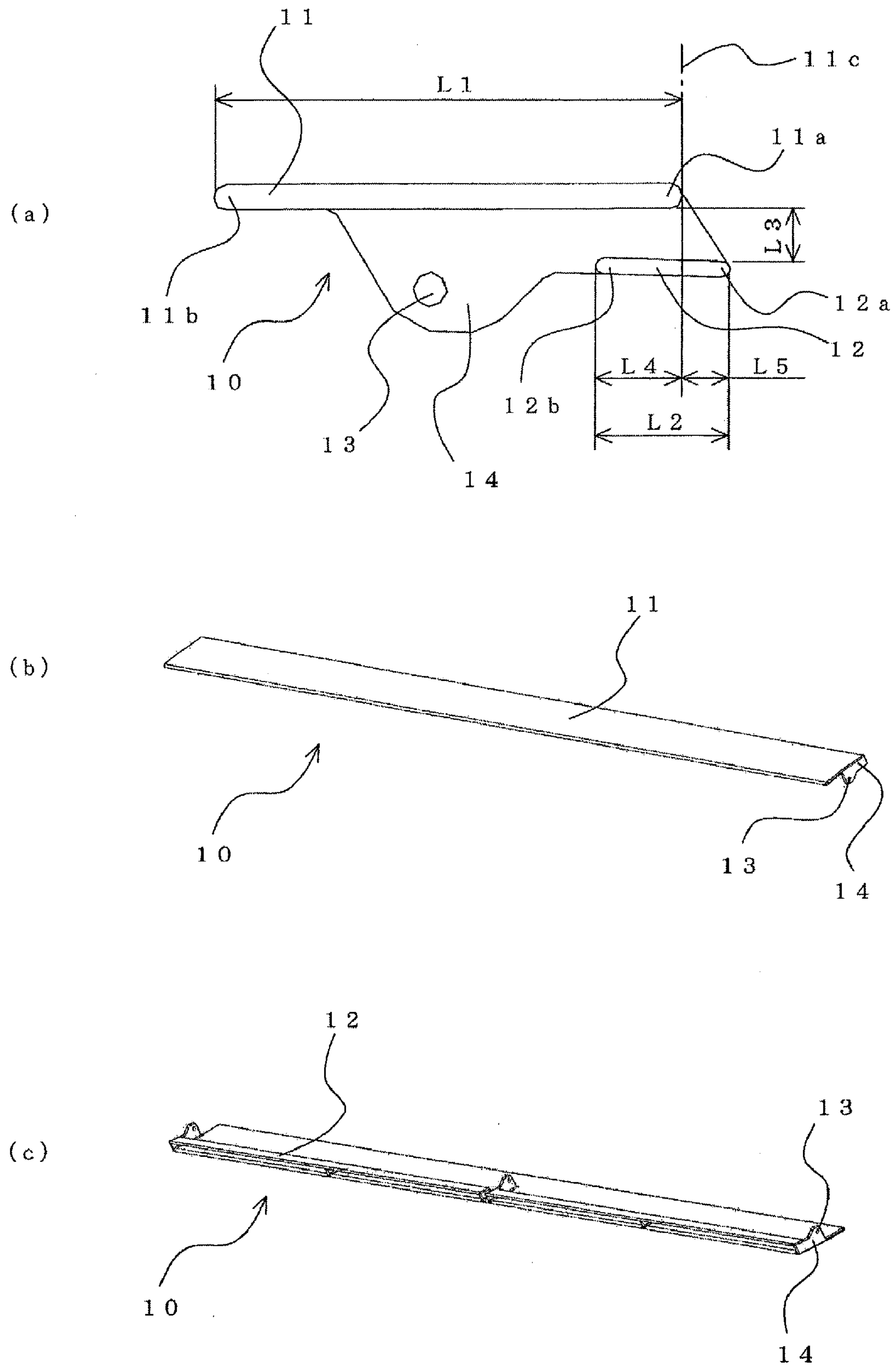

(a)
11
11c
L1
11a
L3
12a
11b
10
13
14
12b
12
L4
L5
L2
(b)
11
10
13
14
(c)
12
13
10
14

FIG. 4

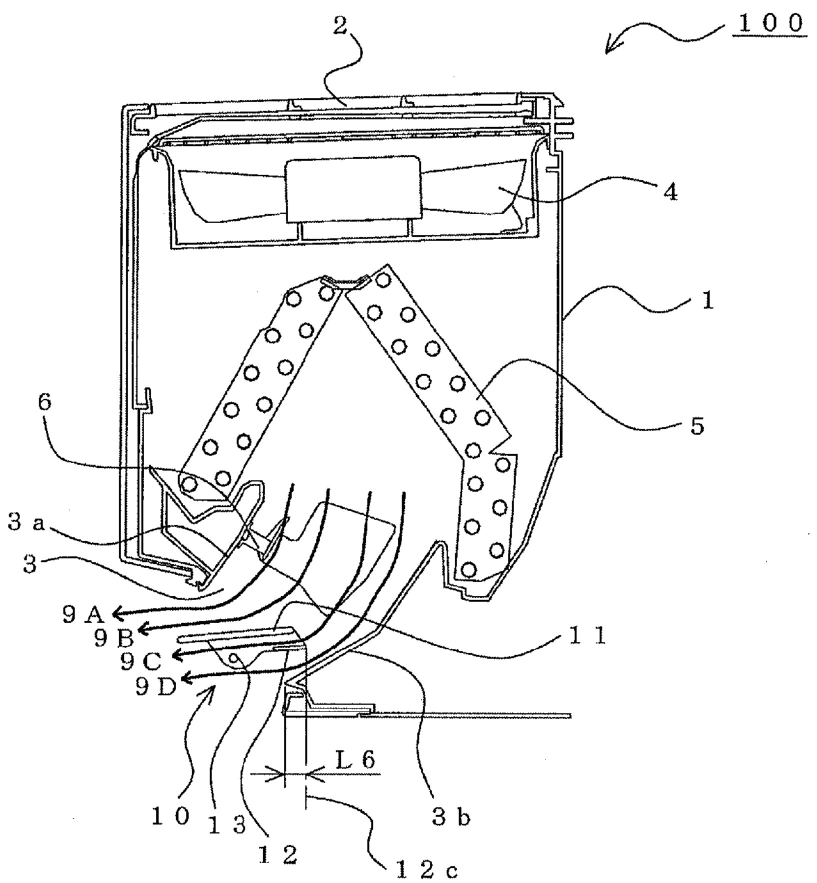
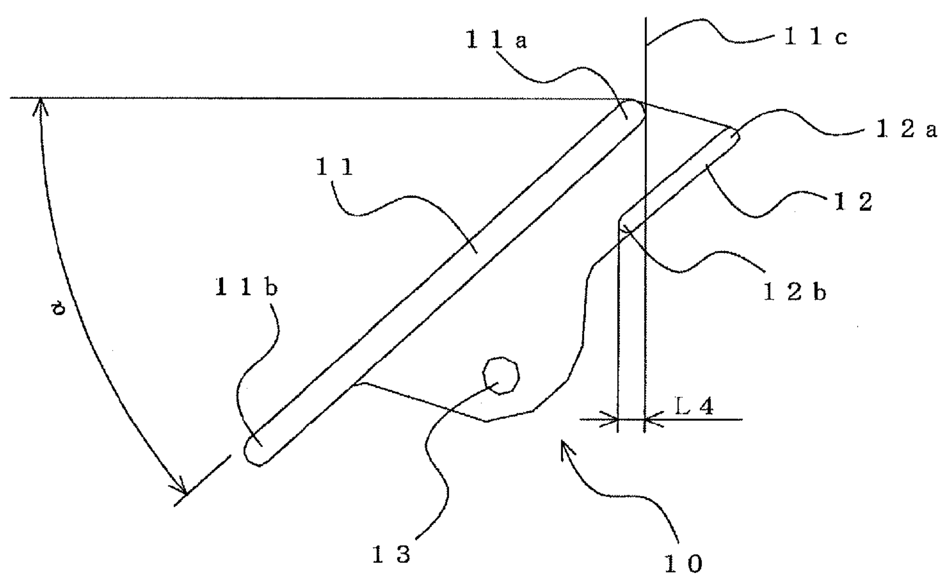
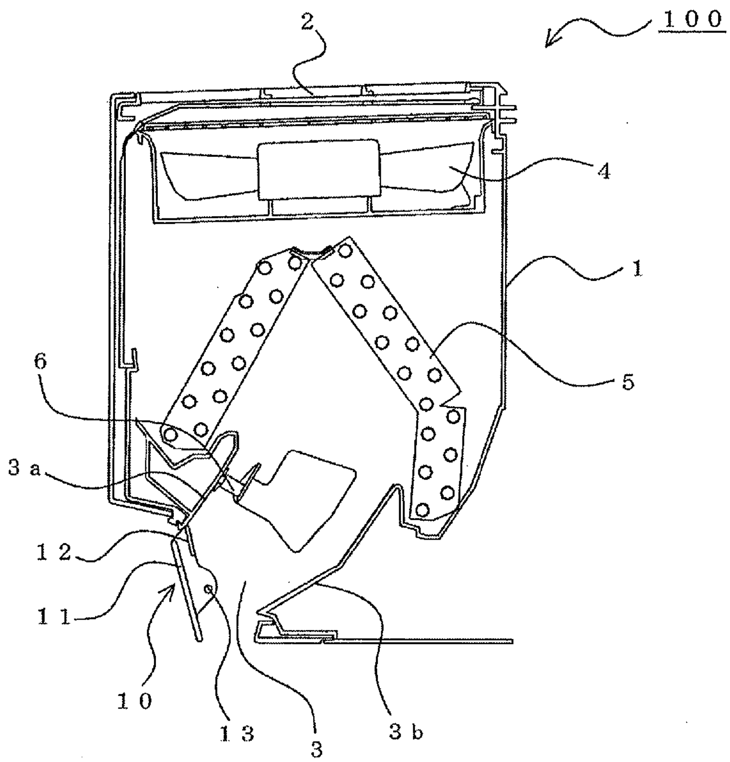

100
2
4
1
5
6
3a
3
9A
9B
9C
9D
11
L6
10
13
12
3b
12c

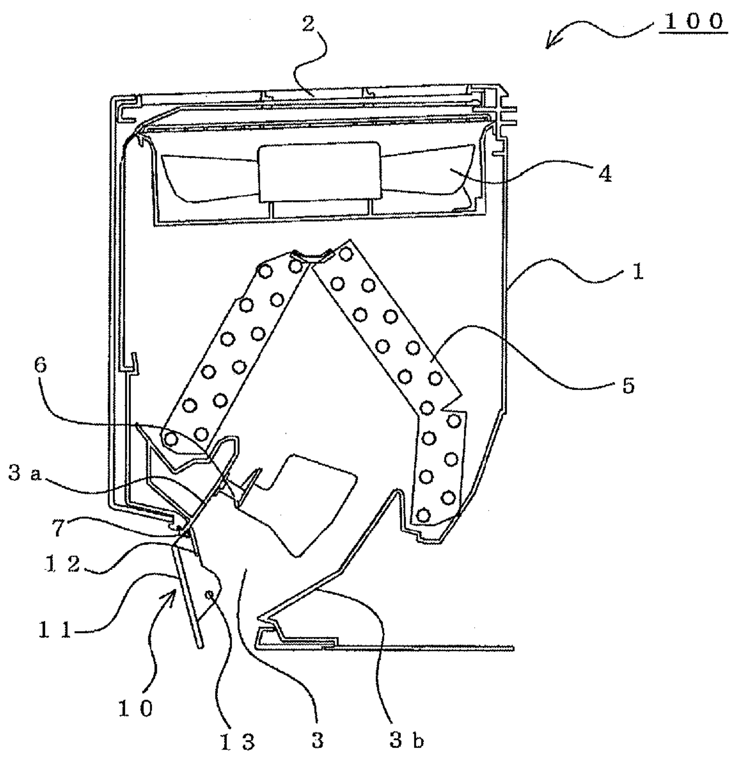
FIG. 5


11a
11c
12a
11
12
12b
11b
α
L4
13
10

F I G. 6



F I G. 7



INDOOR UNIT FOR AIR-CONDITIONING APPARATUS AND AIR-CONDITIONING APPARATUS INCLUDING THE INDOOR UNIT

TECHNICAL FIELD

[0001] The present invention relates to an indoor unit intended for an air-conditioning apparatus and to an air-conditioning apparatus including the indoor unit.

Background Art

[0002] Known indoor units for air-conditioning apparatuses include axial-flow or mixed-flow fans functioning as air-sending devices that allow air in conditioned spaces to flow through the indoor units. An example of such an indoor unit for an air-conditioning apparatus is as follows. "An indoor unit **40** includes a casing **1** having an air inlet **2** in an upper portion thereof and an air outlet **3** in a lower portion of a front face thereof, an axial-flow or mixed-flow fan **4** provided in the casing **1** at a position on the downstream side of the air inlet **2**, and a heat exchanger **5** provided in the casing **1** at a position on the downstream side of the fan **4** and on the upstream side of the air outlet **3** and configured to exchange heat between air blown by the fan **4** and a refrigerant" (see Patent Literature **1**). Such a known indoor unit for an air-conditioning apparatus also includes a louver (also referred to as vane in Patent Literature 1) provided at the air outlet. The louver redirects the air blown out of the air outlet in the vertical direction.

CITATION LIST

Patent Literature

[0003] [Patent Literature 1] WO2010/089920 (Abstract, Paragraph [0012], and FIG. 1)

SUMMARY OF INVENTION

Technical Problem

[0004] As disclosed by Patent Literature **1**, the axial-flow or mixed-flow fan is provided at a position on the downstream side of the air inlet and on the upstream side of the heat exchanger. Furthermore, the axial-flow or mixed-flow fan is oriented such that the air-sending direction thereof (for example, the direction of the rotational axis of the fan if the fan is an axial-flow fan) is orthogonal to the air inlet provided in the upper portion of the casing. That is, in the known indoor unit including an axial-flow or mixed-flow fan, the air having flowed through the heat exchanger, that is, the air flowing toward the air outlet, tends to flow in the vertical direction of the casing. Therefore, the known indoor unit including an axial-flow or mixed-flow fan has the following problem that may occur in a case where the air blown out of the air outlet is redirected in the vertical direction by a louver.

[0005] Some of the air having flowed into the air outlet hits the upper surface of the louver and is redirected in such a manner as to be blown out of the air outlet. The rest of the air having flowed into the air outlet but not having hit the upper surface of the louver is attracted toward the lower surface of the louver by the flow of the air that has hit the upper surface of the louver and by a flow of the air produced along a lower member defining the air outlet. Therefore, in the known indoor unit including an axial-flow or mixed-flow fan, the air flowing into the air outlet and the air flowing out of the air outlet tend to be angled with respect to each other because the flow of the air into the air outlet tends to be produced in the vertical direction of the casing. Consequently, the air flowing below the louver tends to be separated from the lower surface of the louver. Hence, when the indoor unit is in cooling operation, the louver is cooled by cool air (the air cooled by the heat exchanger) that has hit the upper surface of the louver, whereby warm air from the conditioned space gathering in an area below the louver where flow separation may occur is cooled through the louver. This increases the probability that dew condensation may occur on the lower surface of the louver (in particular, a portion of the lower surface of the louver that faces the flow-separation area). Thus, the known indoor unit including an axial-flow or mixed-flow fan has a problem in that dewdrops produced on the lower surface of the louver may gather and form larger dewdrops, and such dewdrops may be discharged into the conditioned space.

[0006] The present invention is to solve the above problem and to provide an indoor unit for an air-conditioning apparatus in which the discharge of dewdrops into a conditioned space that may occur in a cooling operation is suppressed, and an air-conditioning apparatus including the indoor unit.

Solution to Problem

[0007] An indoor unit for an air-conditioning apparatus according to the present invention includes a casing having an air inlet in an upper portion thereof and an air outlet in a lower portion of a front face thereof, an air-sending device provided in the casing and configured to suction air into the casing via the air inlet and to blow the air out of the casing via the air outlet, a heat exchanger provided in the casing and configured to exchange heat between the air suctioned into the casing and a refrigerant, and a louver provided at the air outlet and configured to redirect the air blown out of the air outlet in a vertical direction. The louver includes a main louver and a sub-louver that each have a plate shape and are each configured to rotate around a rotational axis extending in a lateral direction of the casing. In a state where a virtual line connecting a leeward end and a windward end of the main louver is level, the sub-louver is provided below the main louver; a leeward end of the sub-louver is positioned forward by a first predetermined distance with respect to a virtual perpendicular line passing through the windward end of the main louver; and a windward end of the sub-louver is positioned rearward by a second predetermined distance with respect to the virtual perpendicular line passing.

[0008] An air-conditioning apparatus according to the present invention includes the above indoor unit for an air-conditioning apparatus.

Advantageous Effects of Invention

[0009] According to the present invention, the louver includes the main louver and the sub-louver that each have a plate shape and are each configured to rotate around the rotational axis extending in the lateral direction of the casing. In the state where the virtual line connecting the leeward end and the windward end of the main louver is level, the sub-louver is provided below the main louver; the leeward end of the sub-louver is positioned forward by the first predetermined distance with respect to the virtual perpendicular line passing through the windward end of the main louver; and the windward end of the sub-louver is positioned rearward by the second predetermined distance with respect to the virtual perpendicular line. Therefore, some of the air that has flowed into the air outlet and has not hit the upper surface of the main louver hits the upper surface of the sub-louver and flows along the upper surface of the sub-louver. That is, the air that has hit the upper surface of the sub-louver is attracted toward the lower surface of the main louver and flows along the lower surface of the main louver. Hence, the air flowing below the main louver does not tend to be separated from the lower surface of the main louver. Thus, in the cooling operation, the occurrence of dew condensation on the lower surface of the main louver is suppressed, and the discharge of dewdrops into a conditioned space is hence suppressed.

[0010] The application of the present invention is not limited to indoor units including axial-flow or mixed-flow fans. The type of the air-sending device according to the present invention is not limited, and the present invention is applicable to indoor units including various types of air-sending devices.

[0011] For example, in an indoor unit including a cross-flow fan functioning as an air-sending device, the cross-flow fan is provided on the downstream side of the heat exchanger (i.e., between the heat exchanger and the air outlet). Therefore, in the indoor unit including a cross-flow fan, the air flowing into the air outlet can be more easily redirected in such a manner as to be blown out of the air outlet, compared with an indoor unit including an axial-flow or mixed-flow fan, by tilting the direction in which the cross-flow fan blows air. However, since the direction of the air blown out of the air outlet changes, the direction in which the cross-flow fan blows air and the direction in which the air is blown out of the air outlet into the conditioned space cannot be made the same constantly. That is, a louver is also necessary in the indoor unit including a cross-flow fan so as to redirect the air flowing into the air outlet. Therefore, in the indoor unit including a cross-flow fan also, if the angle at which the airflow is redirected by the louver becomes large, the airflow may be separated from the lower surface of the louver and dew condensation may occur on the lower surface of the louver in the cooling operation. Moreover, dewdrops on the lower surface of the louver may gather and form larger dewdrops, and such dewdrops may be discharged into the conditioned space. Considering such circumstances, the present invention is also very effective for the indoor unit including a cross-flow fan.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. **1** is a vertical sectional view of an indoor unit for an air-conditioning apparatus according to Embodiment 1 of the present invention.

[0013] FIG. **2** is a perspective appearance view of the indoor unit for an air-conditioning apparatus according to Embodiment 1 of the present invention.

[0014] FIG. **3** includes diagrams illustrating a louver included in the indoor unit for an air-conditioning apparatus according to Embodiment 1 of the present invention.

[0015] FIG. **4** illustrates airflows produced near an air outlet of the indoor unit for an air-conditioning apparatus according to Embodiment 1 of the present invention.

[0016] FIG. **5** illustrates how a predetermined distance L**4** is set for the louver included in the indoor unit for an air-conditioning apparatus according to Embodiment 1 of the present invention.

[0017] FIG. **6** is a vertical sectional view of an indoor unit for an air-conditioning apparatus according to Embodiment 2 of the present invention.

[0018] FIG. **7** is a vertical sectional view illustrating a modification of the indoor unit for an air-conditioning apparatus according to Embodiment 2 of the present invention.

DESCRIPTION OF EMBODIMENTS

Embodiment 1

[0019] An air-conditioning apparatus (more specifically, an indoor unit for an air-conditioning apparatus) according to Embodiment 1 of the present invention will now be described. Embodiment 1 of the present invention concerns an exemplary case of a wall-mounted indoor unit that includes an axial-flow or mixed-flow fan functioning as an air-sending device. The shapes, sizes, and so forth of units (or elements included in the units) illustrated in the drawings may vary depending on circumstances.

[0020] FIG. **1** is a vertical sectional view of an indoor unit **100** for an air-conditioning apparatus according to Embodiment 1 of the present invention. FIG. **2** is a perspective appearance view of the indoor unit **100**. FIG. **3** includes diagrams illustrating a louver **10** included in the indoor unit **100**. FIG. **3**(*a*) is an enlarged view of the louver **10** illustrated in FIG. **1**. FIG. **3**(*b*) is an upper perspective view of the louver **10** illustrated in FIG. **3**(*a*). FIG. **3**(*c*) is a lower perspective view of the louver **10** illustrated in FIG. **3**(*a*).

[0021] A configuration of the indoor unit **100** will be described with reference to FIGS. **1** to **3**. In Embodiment 1, the left side in FIG. **1** is defined as the front side of the indoor unit **100**.

[0022] The indoor unit **100** supplies conditioned air into a conditioned space, such as a room, by utilizing a refrigeration cycle through which a refrigerant circulates. The indoor unit **100** basically includes the following: a casing **1** having an air inlet **2** via which room air is suctioned into the casing **1** and an air outlet **3** via which the conditioned air is supplied into the conditioned space, a fan **4** provided in the casing **1** and configured to suction the room air via the air inlet **2** and to cause the conditioned air to be blown out of the air outlet **3**, a heat exchanger **5** provided in a flow path extending from the fan **4** to the air outlet **3** and configured to produce the conditioned air by exchanging heat between the refrigerant and the room air, and the louver **10** configured to redirect the flow of the conditioned air in the vertical direction such that the conditioned air is blown out of the air outlet **3**. The air inlet **2** is provided in an upper portion of the casing **1**. The air outlet **3** is provided in a lower portion of the casing **1** (more specifically, in a lower portion of the front face of the casing **1**).

[0023] The fan **4**, which is, for example, an axial-flow or mixed-flow fan, is provided at a position on the downstream side of the air inlet **2** and on the upstream side of the heat exchanger **5**. In general, many indoor units for air-conditioning apparatuses do not have large fans because the spaces in which the indoor units can be installed are limited. Therefore, in Embodiment 1, a plurality of fans **4** having moderate sizes are provided in parallel so that a desired volume of airflow can be produced. More specifically, as illustrated in FIG. **2**, the indoor unit **100** according to Embodiment 1 includes three fans **4** arranged in parallel in the lateral direction of the casing **1**.

[0024] The heat exchanger **5** is provided on the leeward side of the fans **4**. The heat exchanger **5** provided in the casing **1**

has a substantially A shape in sectional view. Such a sectional shape of the heat exchanger **5** is only exemplary and may alternatively be a substantially M or N shape, for example.

[0025] The louver **10** is provided at the air outlet **3** and includes a main louver **11** and a sub-louver **12**. The main louver **11** has a substantially flat plate shape whose longitudinal direction corresponds to the lateral direction of the casing **1**. The sub-louver **12** also has a substantially flat plate shape whose longitudinal direction corresponds to the lateral direction of the casing **1**, as with the main louver **11**. The main louver **11** and the sub-louver **12** are connected to each other at the lateral ends thereof with ribs **14**. In other words, the main louver **11** and the sub-louver **12** according to Embodiment 1 are provided as an integral body. Furthermore, in Embodiment 1, the sub-louver **12** has a width L2 smaller than a width L1 of the main louver **11**.

[0026] The main louver **11** and the sub-louver **12** may each have a slightly curved shape in side sectional view.

[0027] The main louver **11** and the sub-louver **12** configured as above are arranged as illustrated in FIG. **3**. Specifically, the main louver **11** and the sub-louver **12** extend substantially parallel to each other. For example, in the case where the main louver **11** and the sub-louver **12** each have a slightly curved shape in side sectional view, a virtual line connecting a windward end **11***a* and a leeward end **11***b* of the main louver **11** and a virtual line connecting a windward end **12***a* and a leeward end **12***b* of the sub-louver **12** extend substantially parallel to each other. Furthermore, in Embodiment 1, the main louver **11** and the sub-louver **12** are at a predetermined distance L3 of 5 mm to 10 mm from each other.

[0028] In a case where the virtual line connecting the windward end **11***a* and the leeward end **11***b* of the main louver **11** is level, the leeward end **12***b* of the sub-louver **12** is positioned forward by a predetermined distance L**4** with respect to a virtual perpendicular line **11***c* passing through the windward end **11***a* of the main louver **11**. Furthermore, in the case where the virtual line connecting the windward end **11***a* and the leeward end **11***b* of the main louver **11** is level, the windward end **12***a* of the sub-louver **12** is positioned rearward by a predetermined distance L**5** with respect to the virtual perpendicular line **11***c* passing through the windward end **11***a* of the main louver **11**.

[0029] Furthermore, according to Embodiment 1, in the case where the virtual line connecting the windward end **11***a* and the leeward end **11***b* of the main louver **11** is level as illustrated in FIG. **1**, that is, in a case where the virtual line connecting the windward end **12***a* and the leeward end **12***b* of the sub-louver **12** is level, an edge (lower edge) of a lower member **3***b* defining the air outlet **3** is positioned forward by a predetermined distance L**6** with respect to a virtual perpendicular line **12***c* passing through the windward end **12***a* of the sub-louver **12** (see FIG. **1**).

[0030] The predetermined distance L**4** corresponds to the first predetermined distance according to the present invention. The predetermined distance L**5** corresponds to the second predetermined distance according to the present invention. The predetermined distance L**6** corresponds to the third predetermined distance according to the present invention. A specific method of setting the predetermined distances L**4**, L**5**, and L**6** will be described separately below in conjunction with description of operations.

[0031] The ribs **14** included in the louver **10** have pins **13**, respectively, projecting from the outer sides thereof. The pins **13**, that is projections, are rotatably supported by, for example, sidewalls of the casing **1**. That is, the main louver **11** and the sub-louver **12** are configured to rotate around the pins **13** provided on a virtual line extending in the lateral direction of the casing **1**. The main louver **11** and the sub-louver **12** are driven by a motor or the like (not illustrated).

[0032] The indoor unit **100** according to Embodiment 1 also includes a straightening vane **6** provided on an upper member **3***a* defining the air outlet **3**. The straightening vane **6** guides the air having flowed into the air outlet **3** toward the exit of the air outlet **3**.

[0033] (Description of Operations)

[0034] Operations performed by the indoor unit **100** configured as above will now be described.

[0035] When the fans **4** are driven to rotate, the room air is suctioned into the casing **1** via the air inlet **2**. The room air is blown by the fans **4** and flows into the heat exchanger **5** provided on the downstream side. The room air having flowed into the heat exchanger **5** is cooled in a cooling operation or is heated in a heating operation by the refrigerant flowing through the heat exchanger **5**. The air thus conditioned flows into the air outlet **3**. The conditioned air having flowed into the air outlet **3** is redirected in the vertical direction by the louver **10** (i.e., by the main louver **11** and the sub-louver **12**) and is blown out of the air outlet **3** into the conditioned space (i.e., to the outside of the casing **1**). Airflows produced near the air outlet **3** in this process are illustrated in FIG. **4**.

[0036] FIG. **4** illustrates the airflows produced near the air outlet **3** of the indoor unit **100** for an air-conditioning apparatus according to Embodiment 1 of the present invention. FIG. **4** is a sectional view corresponding to FIG. **1**.

[0037] Each fan **4**, which is an axial-flow or mixed-flow fan, is oriented such that the air-sending direction thereof (for example, the direction of the rotational axis of the fan **4** if the fan **4** is an axial-flow fan) is orthogonal to the air inlet **2** provided in the upper portion of the casing **1**. Therefore, the conditioned air having flowed through the heat exchanger **5** generally tends to flow in a vertical direction of the casing **1**, although the direction of the flow slightly changes when passing through the heat exchanger **5**. Hence, the direction in which the conditioned air flows into the air outlet **3** is close to the vertical direction of the casing **1** on the upstream side of the louver **10**, although the flow is redirected toward the exit of the air outlet **3** by the straightening vane **6**. That is, the conditioned air having flowed into the air outlet **3** flows as follows.

[0038] Some of the conditioned air having flowed into an area near the upper member **3***a* defining the air outlet **3** is redirected toward the exit of the air outlet **3** by the straightening vane **6** while being pushed upward by airflow **9**B, to be described below, thereby flowing along the upper member **3***a* defining the air outlet **3** (see airflow **9**A illustrated in FIG. **4**). Some of the conditioned air having flowed into the air outlet **3** on the rear side with respect to the airflow **9**A hits the upper surface of the main louver **11** and flows along the upper surface of the main louver **11** (see the airflow **9**B illustrated in FIG. **4**). Some of the conditioned air having flowed into the air outlet **3** on the rear side with respect to the airflow **9**B flows without hitting the upper surface of the main louver **11**.

[0039] The air flowing on the rear side with respect to the airflow **9**B tends to flow along the lower surface of the main louver **11**. If the direction of such airflow is angled with respect to the direction in which the main louver **11** extends (i.e., the direction in which the conditioned air is blown out of the air outlet **3**), the airflow may be separated from the lower surface of the main louver **11**. Therefore, when the indoor unit **100** is in cooling operation, the main louver **11** is cooled by the cool air that hits the upper surface of the main louver **11**, whereby warm room air gathering in an area below the main louver **11** where flow separation may occur is cooled through the main louver **11**. This increases the probability that dew condensation may occur on the lower surface of the main louver **11** (in particular, a portion of the lower surface of the main louver **11** that faces the flow-separation area). If dewdrops produced on the lower surface of the main louver **11** gather and form larger dewdrops, such dewdrops may be discharged into the room.

[0040] In Embodiment 1, however, since the sub-louver **12** is provided, some of the conditioned air that has not hit the upper surface of the main louver **11** hits the upper surface of the sub-louver **12** and flows along the upper surface of the sub-louver **12** (see airflow **9**C illustrated in FIG. **4**). That is, the conditioned air having hit the upper surface of the sub-louver **12** flows between the main louver **11** and the sub-louver **12** while being attracted toward and flows along the lower surface of the main louver **11**. Therefore, the conditioned air flowing along the lower surface of the main louver **11** does not tend to be separated from the lower surface of the main louver **11**. Thus, in the cooling operation, the occurrence of dew condensation on the lower surface of the main louver **11** is suppressed, and the discharge of dewdrops into the room is hence suppressed. Since the predetermined distance L**3** between the main louver **11** and the sub-louver **12** is set to 5 mm to 10 mm, flow separation does not tend to occur between the main louver **11** and the sub-louver **12**. Consequently, the pressure loss in the conditioned air flowing between the main louver **11** and the sub-louver **12** is reduced. That is, the resistance in the flow path for the airflow **9**C defined between the main louver **11** and the sub-louver **12** is reduced.

[0041] In Embodiment 1, some of the conditioned air that has not hit the upper surface of the sub-louver **12** hits the lower member **3***b* defining the air outlet **3** and flows along the lower member **3***b* defining the air outlet **3** (see airflow **9**D illustrated in FIG. **4**). That is, the conditioned air having hit the lower member **3***b* defining the air outlet **3** is attracted toward the lower surface of the sub-louver **12** and flows along the lower surface of the sub-louver **12**. Therefore, the conditioned air flowing below the sub-louver **12** does not tend to be separated from the lower surface of the sub-louver **12**. Thus, in the cooling operation, the occurrence of dew condensation on the lower surface of the sub-louver **12** is also suppressed, and the discharge of dewdrops into the room is further suppressed.

[0042] Referring to FIG. **5**, as an angle α of the louver **10** (i.e., the main louver **11** and the sub-louver **12**) with respect to the level becomes closer to perpendicular, the predetermined distance L**4** becomes smaller. As the angle α of the louver **10** further becomes further close to perpendicular, the predetermined distance L**4** becomes less than zero; that is, the windward end **11***a* of the main louver **11** and the leeward end **12***b* of the sub-louver **12** become not overlapping each other in the vertical direction in side view. Meanwhile, as the angle α of the louver **10** (i.e., the main louver **11** and the sub-louver **12**) becomes closer to perpendicular, the difference between the angle of the conditioned air flowing into the air outlet **3** and the angle of the conditioned air flowing out of the air outlet **3** becomes smaller. Therefore, flow separation does not tend to occur below the main louver **11**. Hence, in Embodiment 1, the predetermined distance L**4** is set so as to become zero or larger when the angle of the conditioned air flowing into the air outlet **3** (for example, the angle of the rotational axis of the fan **4** if the fan **4** is an axial-flow fan) and the angle of the main louver **11** become respective values that allow dewdrops to be discharged into the room because of the effect produced in the flow-separation area below the main louver **11**. Similarly, in Embodiment 1, the predetermined distance L**6** is set so as to become zero or larger when the angle of the conditioned air flowing into the air outlet **3** (for example, the angle of the rotational axis of the fan **4** if the fan **4** is an axial-flow fan) and the angle of the sub-louver **12** become respective values that allow dewdrops to be discharged into the room because of the effect produced in the flow-separation area below the sub-louver **12**. Furthermore, the predetermined distance L**5** is set on the basis of the predetermined distance L**4** and the width L**2** of the sub-louver **12**. In addition, the main louver **11** and the sub-louver **12** according to Embodiment 1 are arranged such that the predetermined distance L**4** becomes zero when the angle α of the main louver **11** with respect to the level (see FIG. **5**) is 55 degrees. In other words, supposing that the angle of the conditioned air flowing into the air outlet **3** is perpendicular, the main louver **11** and the sub-louver **12** are arranged such that the predetermined distance L**4** becomes zero when the angle formed between the virtual perpendicular line **11***c* and the main louver **11** becomes 35 degrees. Similarly, the sub-louver **12** and the edge of the lower member **3***b* defining the air outlet **3** are arranged such that the predetermined distance L**6** becomes zero when the angle of the sub-louver **12** with respect to the level becomes 55 degrees. In other words, supposing that the angle of the conditioned air flowing into the air outlet **3** is perpendicular, the sub-louver **12** and the edge of the lower member **3***b* defining the air outlet **3** are arranged such that the predetermined distance L**6** becomes zero when the angle formed between the virtual perpendicular line **12***c* and the sub-louver **12** becomes 35 degrees.

[0043] In the indoor unit **100** according to Embodiment 1, the louver **10** includes the main louver **11** and the sub-louver **12**. Furthermore, in the case where the virtual line connecting the windward end **11***a* and the leeward end **11***b* of the main louver **11** is level, the leeward end **12***b* of the sub-louver **12** is positioned forward by the predetermined distance L**4** with respect to the virtual perpendicular line **11***c* passing through the windward end **11***a* of the main louver **11**. Therefore, in the cooling operation, the occurrence of dew condensation on the lower surface of the main louver **11** is suppressed, and the discharge of dewdrops into the room is hence suppressed.

[0044] Furthermore, the width L**2** of the sub-louver **12** is smaller than the width L**1** of the main louver **11**. Therefore, even if dew condensation occurs on the lower surface of the sub-louver **12**, dewdrops produced on the lower surface of the sub-louver **12** do not tend to form larger dewdrops. Hence, the discharge of dewdrops into the room is further suppressed.

[0045] Furthermore, in the case where the virtual line connecting the windward end **12***a* and the leeward end **12***b* of the sub-louver **12** is level, the edge (lower edge) of the lower member **3***b* defining the air outlet **3** is positioned forward by the predetermined distance L**6** with respect to the virtual perpendicular line **12***c* passing through the windward end **12***a* of the sub-louver **12**. Therefore, in the cooling operation, the occurrence of dew condensation on the lower surface of the sub-louver **12** is also suppressed, and the discharge of dewdrops into the room is further suppressed.

[0046] Furthermore, since the straightening vane **6** is provided on the upper member **3***a* defining the air outlet **3**, the conditioned air having flowed into the air outlet **3** is redirected toward the exit of the air outlet **3** by the straightening vane **6**. This reduces the difference between the angle of the conditioned air flowing into the air outlet **3** and the angle of the conditioned air flowing out of the air outlet **3**. Therefore, in the cooling operation, the occurrence of dew condensation on the lower surfaces of the main louver **11** and the sub-louver **12** is further suppressed, and the discharge of dewdrops into the room is further suppressed.

[0047] While the main louver **11** and the sub-louver **12** according to Embodiment 1 share the common pins **13** that together define one rotational axis, the main louver **11** and the sub-louver **12** may alternatively have respective rotational axes. That is, even if the main louver **11** and the sub-louver **12** have respective rotational axes, the effects described in Embodiment 1 are produced, as long as the main louver **11** and the sub-louver **12** are arranged as described above.

[0048] While Embodiment 1 of the present invention concerns a case where the indoor unit **100** includes the fans **4** that are axial-flow or mixed-flow fans, it is obvious that the present invention can be embodied regardless of the type of the fans included in the indoor unit. In an indoor unit including a louver, the flow of air is redirected in such a manner as to be blown out of the air outlet, regardless of the type of fans. Therefore, if the angle at which the airflow is redirected by the louver is large, the airflow produced below the louver may be separated from the lower surface of the louver. This may lead to dew condensation on the lower surface of the louver in the cooling operation. Dewdrops produced on the lower surface of the louver may gather and form larger dewdrops. Such dewdrops may be discharged into the conditioned space. Considering such circumstances, the present invention is effective in suppressing the discharge of dewdrops into the room in all types of indoor units including louvers.

Embodiment 2

[0049] In terms of design improvement, air outlets of some known indoor units are closed by louvers when the indoor units are not in operation. The air outlet **3** of the indoor unit **100** including the main louver **11** and the sub-louver **12** may be closed as described below. In Embodiment 2, elements that are the same as those according to Embodiment 1 are not specifically described, and like functions and elements are denoted by like reference numerals and characters. The term "close" used in Embodiment 2 implies that the inside of the indoor unit **100** is concealed by the louver **10** and does not imply that the air outlet **3** of the indoor unit **100** is completely closed by the louver **10**.

[0050] In the indoor unit **100** according to Embodiment 1, the air outlet **3** is to be closed by the louver **10** by rotating the louver **10**. In such a case, the louver **10** may be rotated in such a direction that the windward end of the louver **10** moves toward the lower member **3***b* defining the air outlet **3** (hereinafter, referring to FIG. **1**, this direction of rotation is referred to as clockwise direction). Alternatively, the louver **10** may be rotated in such a direction that the windward end of the louver **10** moves toward the upper member **3***a* defining the air outlet **3** (hereinafter, referring to FIG. **1**, this direction of rotation is referred to as counterclockwise direction).

[0051] In the case where the louver **10** is rotated in the clockwise direction, since the indoor unit **100** is configured such that the edge of the lower member **3***b* defining the air outlet **3** projects forward so that the occurrence of dew condensation on the sub-louver **12** is suppressed, the sub-louver **12** and the lower member **3***b* defining the air outlet **3** may interfere with each other, preventing the louver **10** from covering the air outlet **3**.

[0052] In contrast, in the case where the louver **10** is rotated in the counterclockwise direction so as to cover the air outlet **3**, the windward end **11***a* of the main louver **11** may need to reach a position that is forward with respect to the edge of the upper member **3***a* defining the air outlet **3** so that the inside of the casing **1** is concealed when seen from below the main louver **11**. In such a case, the windward end **11***a* of the main louver **11** first passes below the edge of the upper member **3***a* defining the air outlet **3** and then reaches the position that is forward of the edge of the upper member **3***a* defining the air outlet **3**. Therefore, consideration needs to be given for preventing the interference between the windward end **11***a* of the main louver **11** and the upper member **3***a* defining the air outlet **3**. Consequently, a large gap may need to be provided between the windward end **11***a* of the main louver **11** and the edge of the upper member **3***a* defining the air outlet **3**. In such a case, the inside of the casing **1** is exposed through the gap, deteriorating the design.

[0053] Hence, in Embodiment 2, the air outlet **3** is covered by the louver **10** as described below, and the design is thus improved.

[0054] FIG. **6** is a vertical sectional view of an indoor unit **100** for an air-conditioning apparatus according to Embodiment 2 of the present invention.

[0055] As illustrated in FIG. **6**, the indoor unit **100** according to Embodiment 2 is configured as follows. The louver **10** is configured to rotate in the counterclockwise direction in such a manner as to cover the air outlet **3**. Furthermore, in a state where the windward end **11***a* of the main louver **11** faces the edge of the upper member **3***a* defining the air outlet **3**, a gap is produced between the windward end **11***a* of the main louver **11** and the upper member **3***a* defining the air outlet **3** for the prevention of interference therebetween. Furthermore, the main louver **11** and the sub-louver **12** are configured to rotate around the common pins **13**. Therefore, when the louver **10** is rotated in the counterclockwise direction, the windward end **12***a* of the sub-louver **12** rotates about the pins **13** and on the outer side with respect to the windward end **11***a* of the main louver **11**, and comes into contact with the upper member **3***a* defining the air outlet **3**. Accordingly, the gap between the windward end **11***a* of the main louver **11** and the edge of the upper member **3***a* defining the air outlet **3** is covered by the sub-louver **12**. Thus, when the indoor unit **100** is not in operation, the air outlet **3** is covered by the louver **10**, providing the beauty of appearance. Hence, the indoor unit **100** according to Embodiment 2 has improved design in the state where the indoor unit **100** is not in operation.

[0056] In FIG. **6**, the louver **10** is stopped by directly bringing the windward end **12***a* of the sub-louver **12** into contact with the upper member **3***a* defining the air outlet **3**. Alternatively, referring to FIG. **7**, the louver **10** may be stopped by bringing the windward end **12***a* of the sub-louver **12** into contact with a stopper **7** projecting from the upper member **3***a* defining the air outlet **3**. In the case where the louver **10** is stopped by directly bringing the windward end **12***a* of the sub-louver **12** into contact with the upper member **3***a* defining the air outlet **3**, the windward end **12***a* of the sub-louver **12** and the upper member **3***a* defining the air outlet **3** are in line contact with each other. In such a case, the points of contact between the two may vary with dimensional errors of relevant components, assembly errors, and the like. Therefore, in the case where the louver **10** is stopped by directly bringing the windward end **12***a* of the sub-louver **12** into contact with the upper member **3***a* defining the air outlet **3**, the position where the louver **10** (the main louver **11** and the sub-louver **12**) stops may vary with different indoor units **100**.

[0057] In contrast, in the case where the louver **10** is stopped by bringing the windward end **12***a* of the sub-louver **12** into contact with the stopper **7**, the windward end **12***a* of the sub-louver **12** and the stopper **7** are in point contact with each other. Therefore, the variation in the position where the louver **10** (the main louver **11** and the sub-louver **12**) stops occurring with dimensional errors of relevant components, assembly errors, and the like is reduced. Hence, in the case where the louver **10** is stopped by bringing the windward end **12***a* of the sub-louver **12** into contact with the stopper **7**, the indoor unit **100** has much improved design in the state where the indoor unit **100** is not in operation.

REFERENCE SIGNS LIST

[0058] **1**: casing
[0059] **2**: air inlet
[0060] **3**: air outlet
[0061] **3***a*: upper member
[0062] **3***b*: lower member
[0063] **4**: fan
[0064] **5**: heat exchanger
[0065] **6**: straightening vane
[0066] **7**: stopper
[0067] **10**: louver
[0068] **11**: main louver
[0069] **11***a*: windward end
[0070] **11***b*: leeward end
[0071] **11***c*: virtual perpendicular line
[0072] **12**: sub-louver
[0073] **12***a*: windward end
[0074] **12***b*: leeward end
[0075] **12***c*: virtual perpendicular line
[0076] **13**: pin
[0077] **14**: rib
[0078] **100**: indoor unit

1. An indoor unit for an air-conditioning apparatus, comprising:
a casing having an air inlet in an upper portion thereof and an air outlet in a lower portion of a front face thereof;
an air-sending device provided in the casing and configured to suction air into the casing via the air inlet and to blow the air out of the casing via the air outlet;
a heat exchanger provided in the casing and configured to exchange heat between the air suctioned into the casing and a refrigerant; and
a louver provided at the air outlet and configured to redirect the air blown out of the air outlet in a vertical direction, wherein
the louver includes a main louver and a sub-louver that each have a plate shape and are each configured to rotate around a rotational axis extending in a lateral direction of the casing, and
in a state where a virtual line connecting a leeward end and a windward end of the main louver is level,
the sub-louver is provided below the main louver;
a leeward end of the sub-louver is positioned forward by a first predetermined distance with respect to a virtual perpendicular line passing through the windward end of the main louver; and
a windward end of the sub-louver is positioned rearward by a second predetermined distance with respect to the virtual perpendicular line.

2. The indoor unit for an air-conditioning apparatus of claim **1**, wherein
the air-sending device includes a plurality of axial-flow or mixed-flow fans that are provided in parallel on a downstream side of the air inlet, and
the heat exchanger is provided on the downstream side of the plurality of fans.

3. The indoor unit for an air-conditioning apparatus of claim **1**, wherein the sub-louver has a smaller width than the main louver in side sectional view.

4. The indoor unit for an air-conditioning apparatus of claim **1**,
wherein, in a state where the sub-louver is provided such that a virtual line connecting the leeward end and the windward end thereof is level, a lower edge of the air outlet is positioned forward by a third predetermined distance with respect to the windward end of the sub-louver.

5. The indoor unit for an air-conditioning apparatus of claim **1**, further comprising a straightening vane provided at an upper edge of the air outlet.

6. The indoor unit for an air-conditioning apparatus of claim **1**, wherein the main louver and the sub-louver are configured to rotate around a common rotational axis, and
when the main louver and the sub-louver are rotated about the rotational axis, the windward end of the sub-louver comes into contact with an upper edge of the air outlet and the main louver and the sub-louver cover the air outlet.

7. The indoor unit for an air-conditioning apparatus of claim **6**, further comprising a stopper that is a projection provided on the upper edge of the air outlet,
wherein the windward end of the sub-louver is configured to come into contact with the stopper.

8. An air-conditioning apparatus comprising the indoor unit for an air-conditioning apparatus of claim **1**.

* * * * *