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Ooga

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(54) AIR FLOW METER HAVING A FLOW RATE SENSOR AND A PHYSICAL QUANTITY SENSOR

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(30) **Foreign Application Priority Data**

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G01F 5/00 (2006.01)
G01F 1/684 (2006.01)
G01F 1/692 (2006.01)
G01F 15/12 (2006.01)

(52) **U.S. Cl.**
CPC ***G01F 1/692*** (2013.01); ***G01F 1/6842*** (2013.01); ***G01F 5/00*** (2013.01); *G01F 15/12* (2013.01)

(58) **Field of Classification Search**
CPC G01F 1/692; G01F 1/6842; G01F 15/12
USPC 73/114.32
See application file for complete search history.

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(57) **ABSTRACT**

An air flow meter has a housing, a flow rate sensor, and a physical-quantity measuring sensor. The housing therein defines a bypass passage into which a part of air flowing in a duct flows. The flow rate sensor is disposed in the bypass passage. The physical-quantity measuring sensor measures a physical quantity of air flowing in the duct and is disposed separately from the flow rate sensor. The housing has a recessed portion that is recessed from an inner wall surface of the bypass passage and that has a blind-passage shape. The physical-quantity measuring sensor is disposed in the recessed portion.

8 Claims, 8 Drawing Sheets

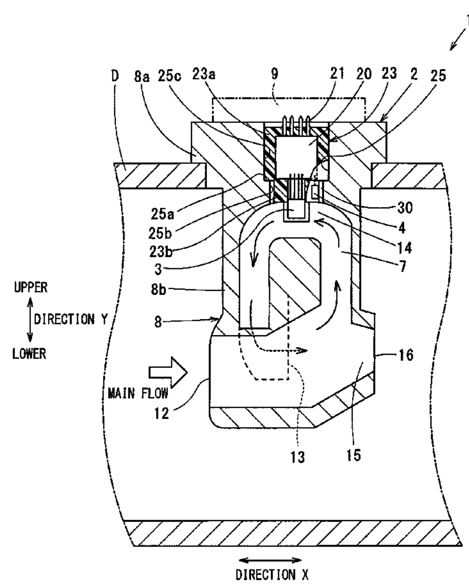
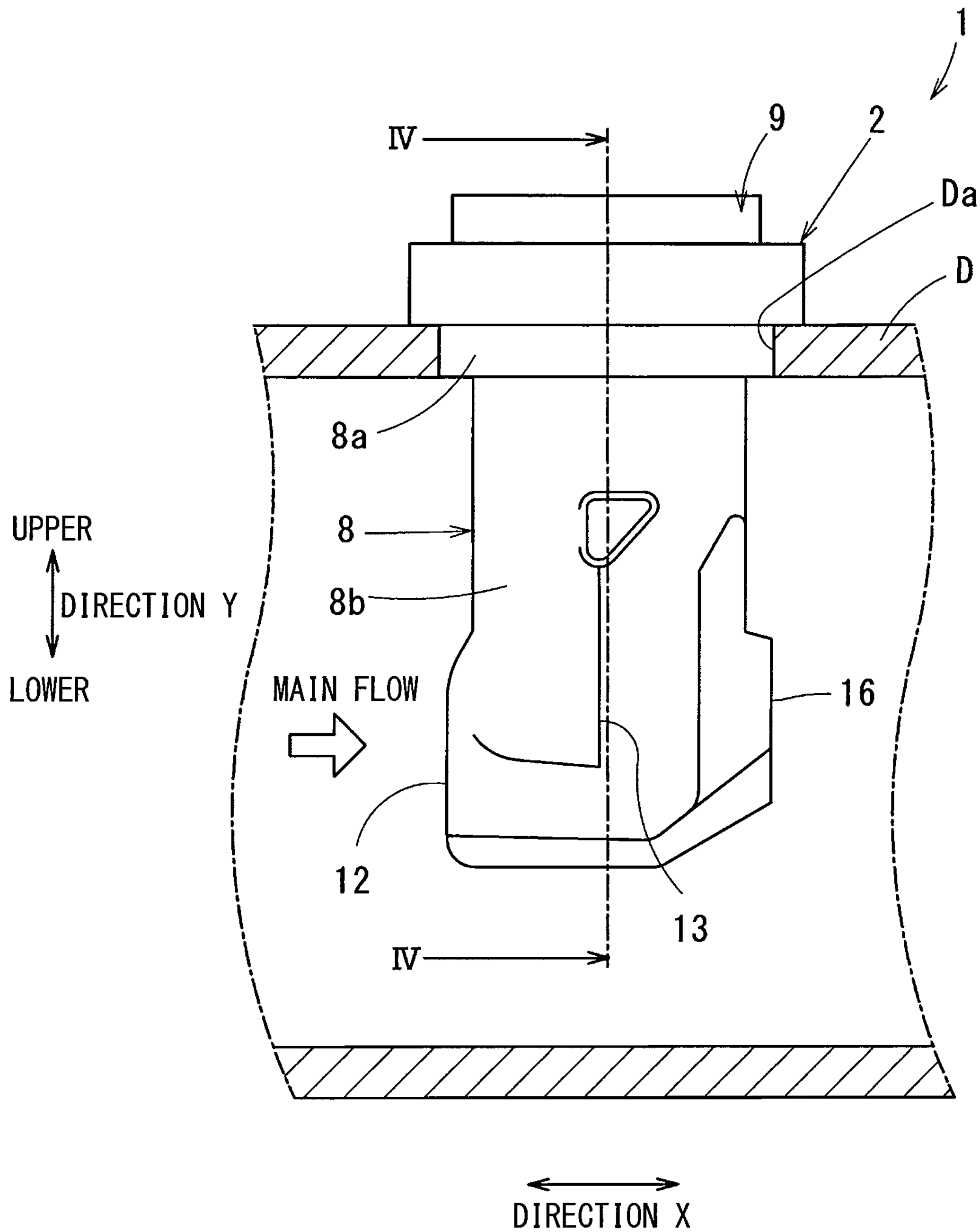


FIG. 1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9
2
Da
D
IV
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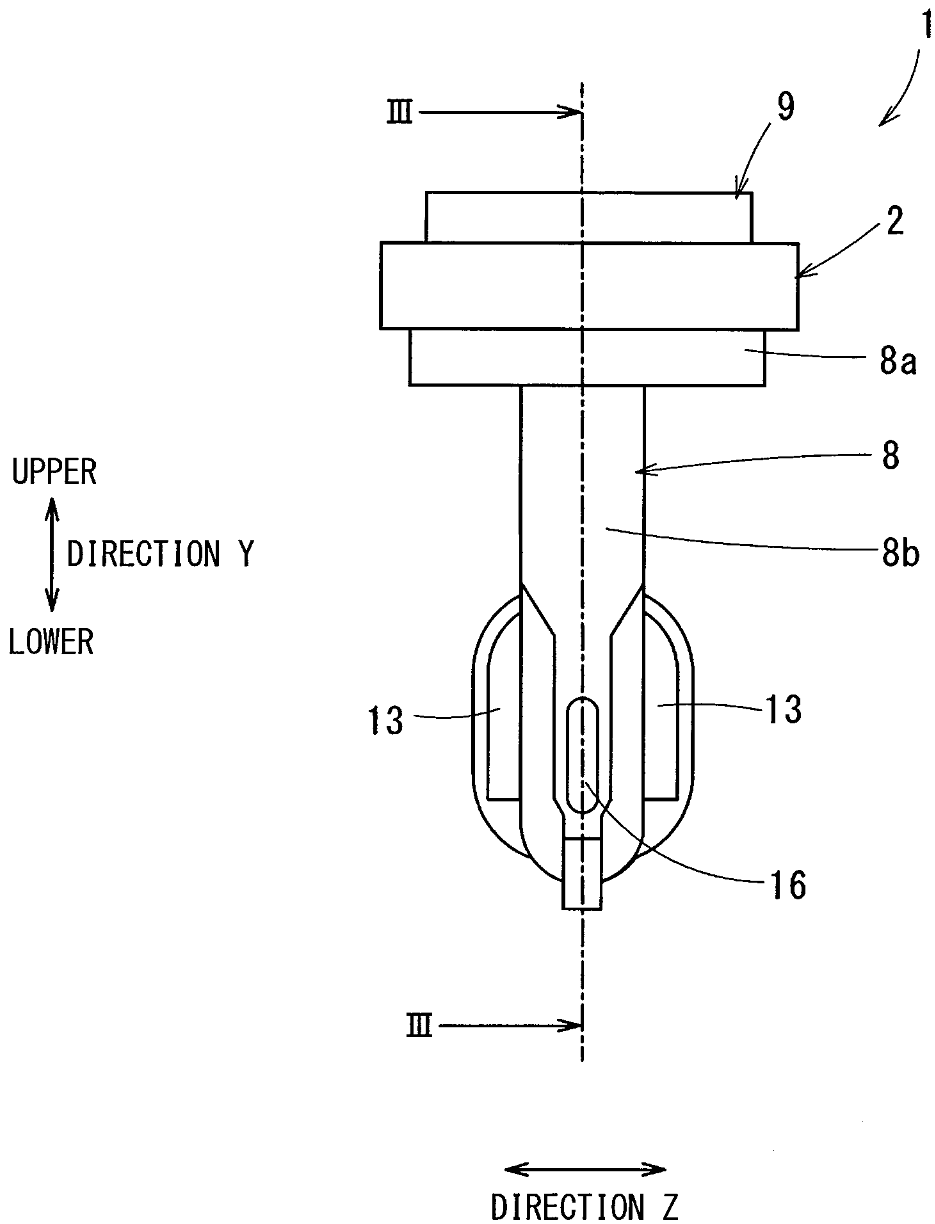
UPPER
DIRECTION Y
LOWER
MAIN FLOW
16
12
13
IV
DIRECTION X

FIG. 2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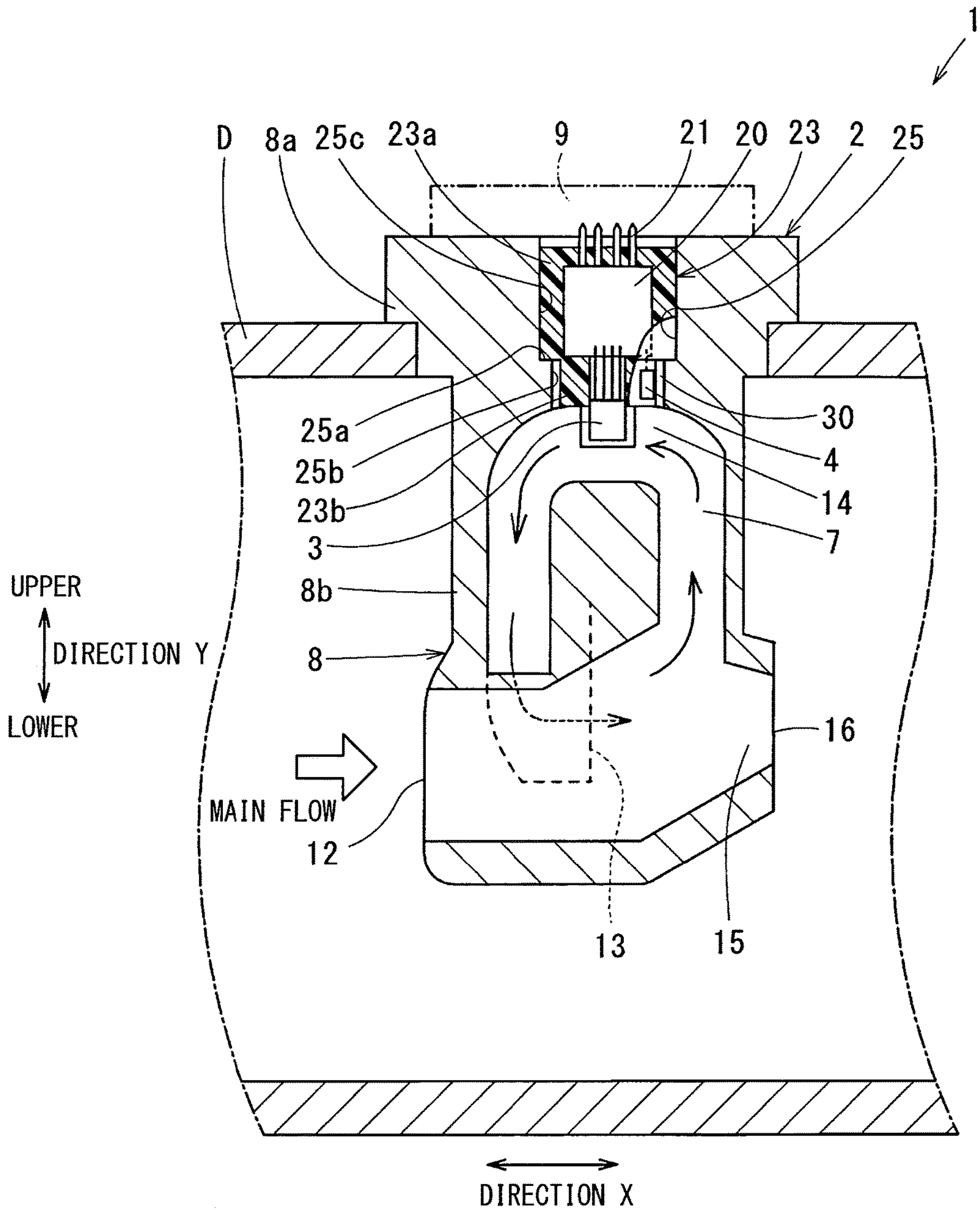
DIRECTION Z

FIG. 3


1
D
8a
25c
23a
9
21
20
23
2
25
25a
25b
23b
3
8b
8
30
4
14
7
16
UPPER
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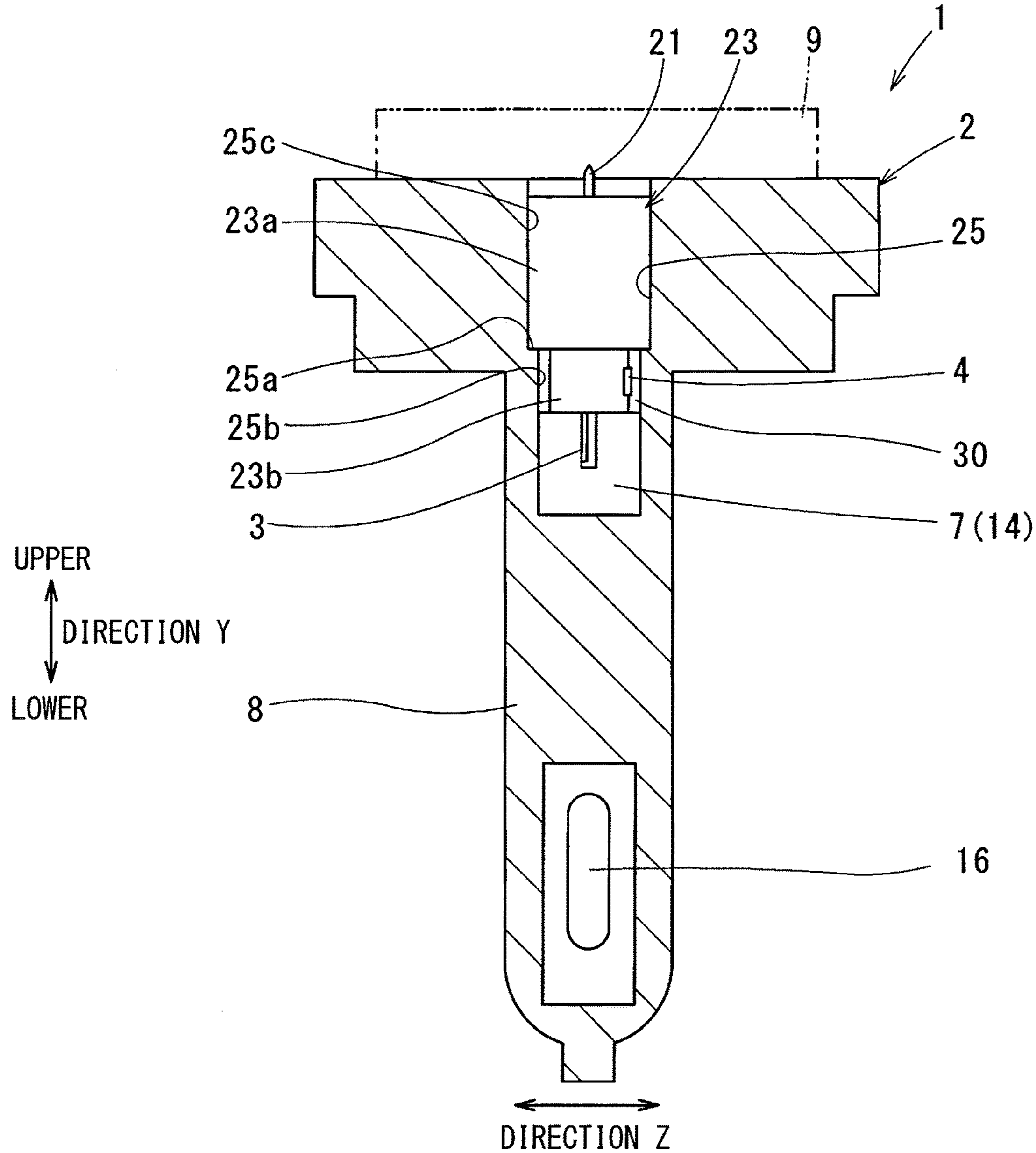
LOWER
MAIN FLOW
12
13
15
DIRECTION X

FIG. 4


1
21
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23a
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25a
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7(14)
UPPER
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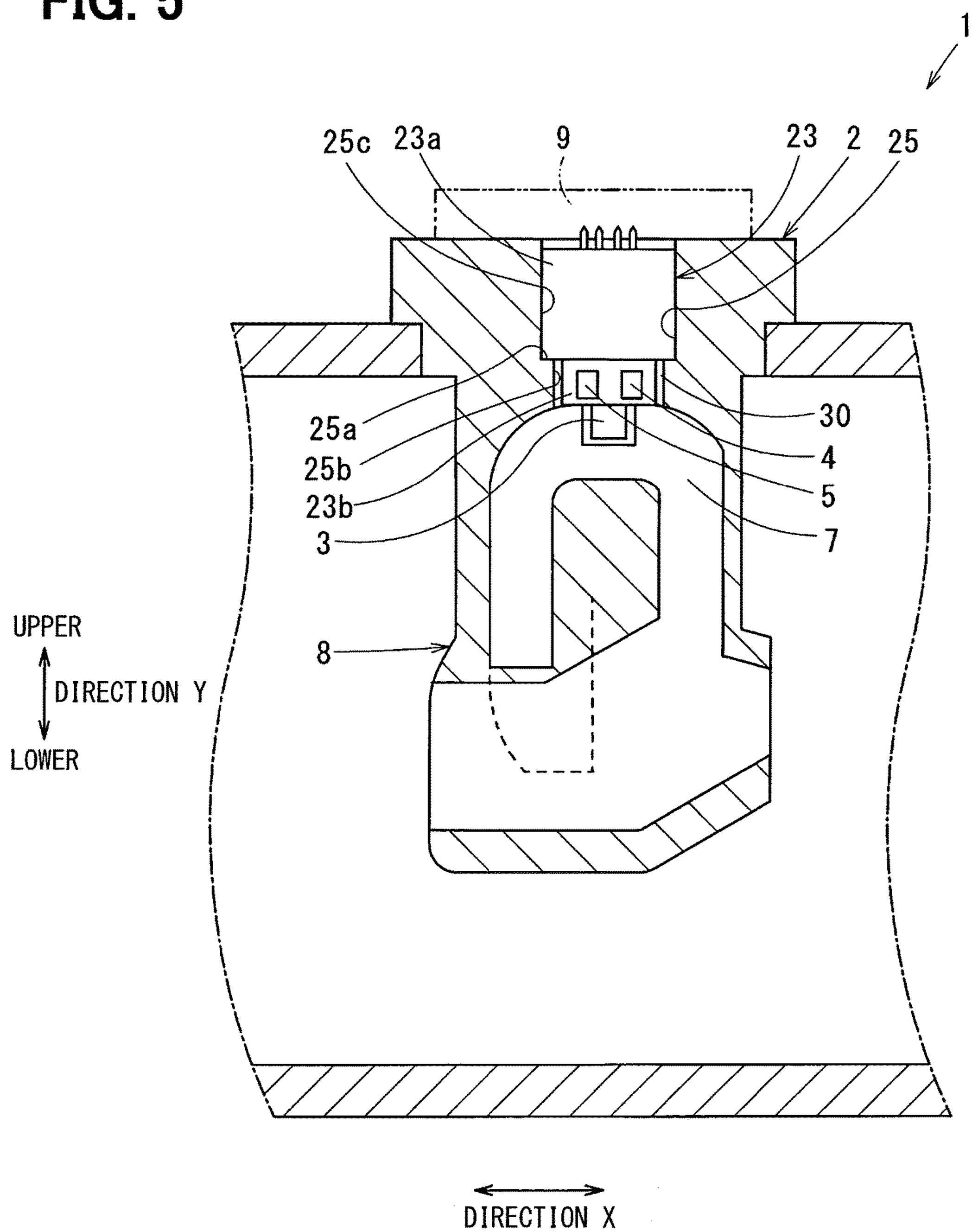
LOWER
8
16
DIRECTION Z

FIG. 5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9
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4
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7
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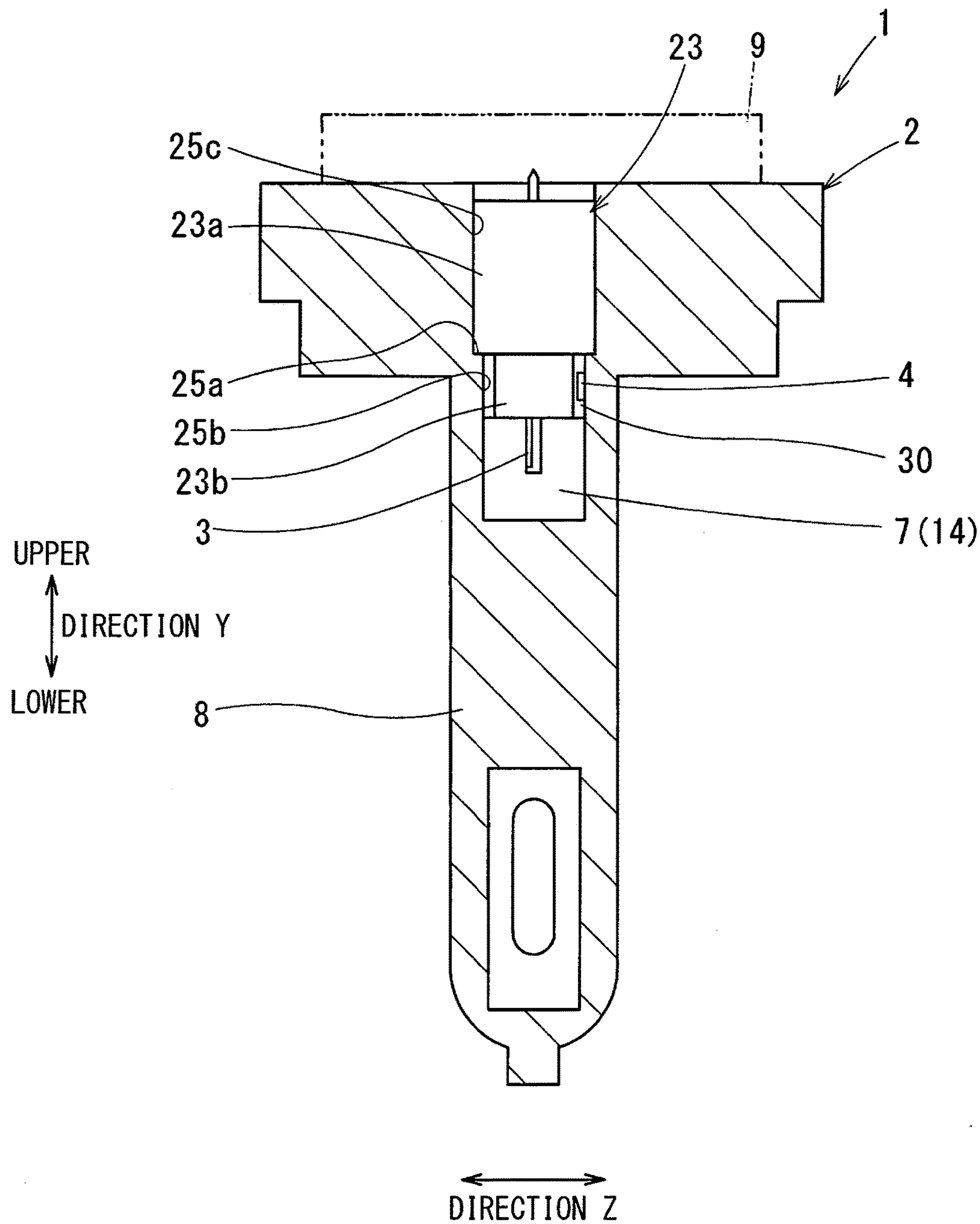
DIRECTION Y
LOWER
DIRECTION X

FIG. 6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23
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2
25c
23a
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25b
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23b
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7(14)
UPPER
DIRECTION Y
LOWER
8
DIRECTION Z

FIG. 7

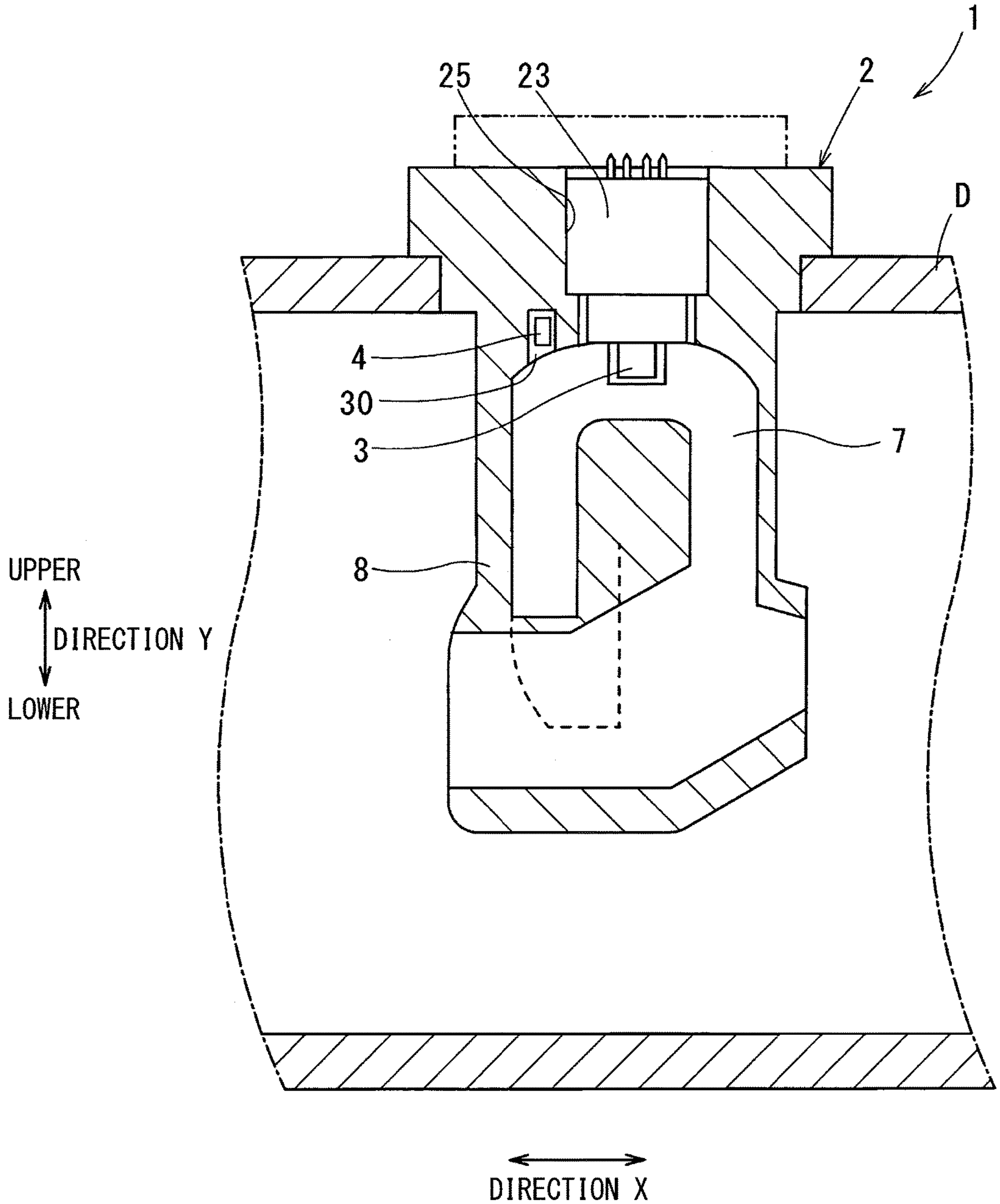
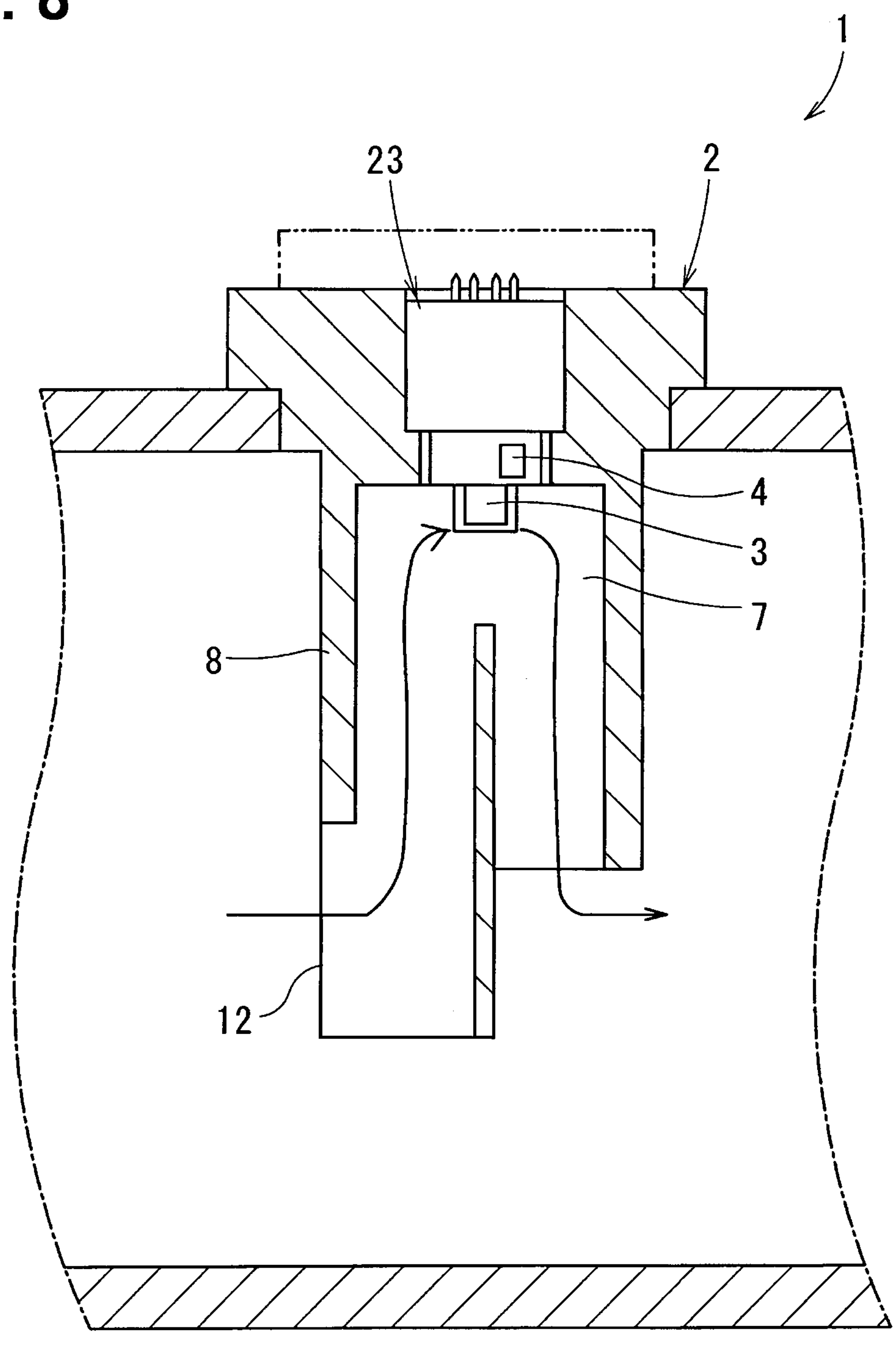


FIG. 8



AIR FLOW METER HAVING A FLOW RATE SENSOR AND A PHYSICAL QUANTITY SENSOR

CROSS REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Application No. 2014-132897 filed on Jun. 27, 2014, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to an air flow meter measuring a flow rate of intake air for an internal combustion engine.

BACKGROUND

Conventionally, an air flow meter capable of detecting humidity is known, and Patent Document 1 (JP 5178388 B2 corresponding to US 2010/0031737 A1 and US 2012/0079879 A1) describes such an air flow meter. An air flow meter described in Patent Document 1 has a flow rate sensor and a humidity sensor. The flow rate sensor is disposed in an auxiliary air passage into which a part of intake air flows. The humidity sensor is disposed in a secondary auxiliary air passage branched from the auxiliary air passage. The secondary auxiliary air passage has an inlet through which air flows from the auxiliary air passage into the secondary auxiliary air passage and an outlet from which the air returns to the auxiliary air passage from the secondary auxiliary air passage.

However, according to studies conducted by the inventor of the present disclosure, dust may be adhered easily to the humidity sensor that is disposed in the secondary auxiliary air passage since large amount of air flows in the secondary auxiliary air passage. That is, the air flow meter may be contaminated easily by dust, in other words, the air flow meter may have a low contamination resistance.

SUMMARY

The present disclosure addresses at least one of the above issues. Thus, it is an objective of the present disclosure to provide an air flow meter which has a physical-quantity measuring sensor separately from a flow rate sensor and with which an adhesion of dust to the physical-quantity measuring sensor can be suppressed.

An air flow meter has a housing, a flow rate sensor, and a physical-quantity measuring sensor. The housing therein defines a bypass passage into which a part of air flowing in a duct flows. The flow rate sensor is disposed in the bypass passage. The physical-quantity measuring sensor measures a physical quantity of air flowing in the duct and is disposed separately from the flow rate sensor. The housing has a recessed portion that is recessed from an inner wall surface of the bypass passage and that has a blind-passage shape. The physical-quantity measuring sensor is disposed in the recessed portion.

According to the above-described configuration, since less amount of air flows in the recessed portion, and the physical-quantity measuring sensor is disposed in the recessed portion, an adhesion of dust to the physical-quantity measuring sensor can be suppressed. That is, a contamination resistance of the physical-quantity measuring sensor can be improved in the air flow meter having the physical-quantity measuring sensor separately from the flow rate sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a diagram illustrating an air flow meter of a first embodiment;

FIG. **2** is a plane view illustrating the air flow meter when viewed from an upstream side in a main flow direction of the first embodiment;

FIG. **3** is a sectional view taken along a line III-III shown in FIG. **2**;

FIG. **4** is a sectional view taken along a line IV-IV shown in FIG. **1**;

FIG. **5** is a partial sectional view illustrating an air flow meter of a second embodiment;

FIG. **6** is a partial sectional view illustrating an air flow meter of a third embodiment;

FIG. **7** is a partial sectional view illustrating an air flow meter of a modification; and

FIG. **8** is a partial sectional view illustrating an air flow meter of a modification.

DETAILED DESCRIPTION

Embodiments of the present disclosure will be described hereafter referring to drawings. In the embodiments, a part that corresponds to a matter described in a preceding embodiment may be assigned with the same reference number, and redundant explanation for the part may be omitted. When only a part of a configuration is described in an embodiment, another preceding embodiment may be applied to the other parts of the configuration. The parts may be combined even if it is not explicitly described that the parts can be combined. The embodiments may be partially combined even if it is not explicitly described that the embodiments can be combined, provided there is no harm in the combination.

First Embodiment

An air flow meter **1** of a first embodiment will be described hereafter referring to FIGS. **1** to **4**.

The air flow meter **1** may measure a flow rate of intake air for an internal combustion engine (i.e., an engine) for a vehicle. The air flow meter **1** is attached to a duct D that is connected to a downstream side of an air cleaner. The duct D has an attachment hole Da that has a circular shape in cross section and passes through a wall of the duct D in a thickness direction. The air flow meter **1** is inserted to an inside of the duct D from the attachment hole Da.

The air flow meter **1** has a housing **2**, a flow rate sensor **3**, and a humidity sensor **4**. The humidity sensor **4** is a physical-quantity measuring sensor that is disposed separately from the flow rate sensor **3** and measures a physical quantity.

The housing **2** has a housing body **8** and a resin portion **9**. The housing body **8** defines a bypass passage **7** to which a part of air flowing in the duct D flows to be a target air. The housing body **8** is molded in a primary molding step, and the resin portion **9** is molded in a secondary molding step.

The housing body **8** has a fitting portion **8***a* fitting to the attachment hole Da and a passage defining portion **8***b* extending from the fitting portion **8***a* to an inside of the duct D. As shown in FIG. **1**, the fitting portion **8***a* has an outer surface facing a wall surface (i.e., an inner surface) defining the attachment hole Da in a radial direction of the fitting portion **8***a*. A clearance between the outer surface of the fitting portion **8***a* and the wall surface defining the attachment hole Da is sealed completely (i.e., gastightly).

The passage defining portion **8***b* extends from the fitting portion **8***a* into the duct D and defines the bypass passage **7** into which a part of air flowing in the duct D flows to be the target air.

Hereafter, a flow direction of air flowing in the duct D will be referred to as a main flow direction. The main flow direction is parallel with a direction in which the duct D extends and is also parallel with a direction X shown in FIG. **1**. A direction in which the housing body **8** extends will be referred to as a direction Y (i.e., an upper-lower direction). In a state of showing in FIG. **1**, the passage defining portion **8***b* extends from the fitting portion **8***a* toward a lower side in the direction Y, and an opposite side that is opposite to the lower side in the direction Y will be referred to as an upper side. A direction perpendicular to both the direction X and the direction Y will be referred to as a direction Z.

A constitution of the bypass passage **7** will be described referring to FIG. **3**. The bypass passage **7** has an intake port **12** opening toward an upstream side in the main flow direction and an emitting port **13** opening toward a downstream side in the main flow direction. For example, the bypass passage **7** guides air (i.e., intake air) flowing into the bypass passage **7** from the intake port **12** to circulate, and the air flows out of the bypass passage **7** from the emitting port **13**. The bypass passage **7** has an area **14** (illustrated as a straight portion of the bypass passage **7**) in which fluid (i.e., air) flows in a direction that is opposite to the main flow direction, and the flow rate sensor **3** is disposed in the area **14**. The bypass passage **7** is branched into two passages on a downstream side of the flow rate sensor **3**, and each of the two passages has the emitting port **13** in both side surfaces of the housing **2** in the direction Z as shown in FIG. **2**.

The bypass passage **7** is connected with a dust emitting passage **15** on an upstream side of the flow rate sensor **3**, and the dust emitting passage **15** emits dust. Specifically, dust flowing into the bypass passage **7** is emitted from a dust emitting outlet **16** of the dust emitting passage **15** to return to the duct D without flowing to the flow rate sensor **3** as shown in FIG. **3**.

The flow rate sensor **3** outputs an electric signal such as a pressure signal based on a flow rate of air flowing in the bypass passage **7**. Specifically, the flow rate sensor **3** has a semiconductor board having a membrane, and a heat generating element and a thermal sensitive element that are made of thin-film resistive element are disposed on the membrane.

The flow rate sensor **3** is modularized with a circuit module **20**, an external terminal (i.e., a terminal) **21**, and the like to constitute a sensor assembly **23**. In an assembly of the sensor assembly **23**, the circuit module **20** and the external terminal **21** are assembled in the sensor assembly **23** by insert molding.

The circuit module **20** processes the electrical signal from the flow rate sensor **3** and therein has a circuit board (not shown). The external terminal **21** is a terminal that outputs an electrical signal processed in the circuit module **20** to an electric control unit (i.e., an ECU) (not shown) through a connector (not shown).

The sensor assembly **23** is inserted and fixed in the housing body **8** such that a sensing portion of the flow rate sensor **3** is exposed in the area **14** of the bypass passage **7**.

Specifically, the housing body **8** has an insert hole **25** that is a housing space housing the sensor assembly **23**, and the sensor assembly **23** is inserted to the insert hole **25** such that the flow rate sensor **3** is exposed in the bypass passage **7** as shown in FIG. **3**.

The insert hole **25** passes through the housing body **8**. The insert hole **25** is a stepped hole, in other words, the insert hole **25** has different dimensions in the direction Z and in the direction X. Specifically, a dimension of the insert hole **25** in the direction Z and in the direction X is changed at a step surface **25***a*. A dimension of the insert hole **25** in the direction Z and in the direction X on a lower side of the step surface **25***a* in the direction Y is smaller than that on an upper side of the step surface **25***a* in the direction Y. That is, as shown in FIG. **3**, the insert hole **25** has a lower hole portion **25***b* that is located on the lower side of the step surface **25***a* in the direction Y and an upper hole portion **25***c* that is located on the upper side of the step surface **25***a* in the direction Y. The dimension of the lower hole portion **25***b* in the direction Z and in the direction X is smaller than the dimension of the upper hole portion **25***c* in the direction Z and in the direction X. The lower hole portion **25***b* is open toward the bypass passage **7**.

The sensor assembly **23** has a large diameter portion **23***a* and a small diameter portion **23***b*. The large diameter portion **23***a* is larger than the small diameter portion **23***b* in dimension in the direction Z and in the direction X. The large diameter portion **23***a* is disposed in the upper hole portion **25***c* and fits to the step surface **25***a* in the direction Y. The small diameter portion **23***b* is disposed in the lower hole portion **25***b* on a lower side of the large diameter portion **23***a* in the direction Y. The flow rate sensor **3** is disposed on a lower side of the small diameter portion **23***b* in the direction Y to be exposed in the bypass passage **7**.

The resin portion **9** is molded on a condition where the sensor assembly **23** is located in the housing body **8**.

The humidity sensor **4** outputs an electric signal such as a voltage signal based on a detected humidity of air flowing in the duct D. The humidity sensor **4** uses, for example, a variation of permittivity of a polymer membrane that is caused by a variation of relative humidity.

The housing **2** has a recessed portion **30** recessed from an inner wall surface of the bypass passage **7**. The recessed portion **30** has a blind-passage shape, in other words, one end of the recessed portion **30** in the direction Y is open, and the other end of the recessed portion **30** in the direction Y is closed. The humidity sensor **4** is disposed in the recessed portion **30**. The housing **2** has the insert hole **25** that houses the sensor assembly **23** such that the flow rate sensor **3** is exposed in the bypass passage **7**, and a part of the insert hole **25** defines the recessed portion **30**.

That is, in the present embodiment, the recessed portion **30** is defined by the lower hole portion **25***b* in which the small diameter portion **23***b* is disposed. A clearance is defined between an inner surface of the lower hole portion **25***b* and an outer surface of the small diameter portion **23***b* in a radial direction of the insert hole **25**. The clearance is open to the bypass passage **7** on a lower side in the direction Y and is closed by the large diameter portion **23***a* on an upper side in the direction Y. As a result, the clearance has a blind-passage shape, in other words, one end of the clearance in the direction Y is open, and the other end of the clearance in the direction Y is closed. Thus, the clearance defines the recessed portion **30**.

The humidity sensor **4** is disposed in the recessed portion **30**.

In the present embodiment, the humidity sensor **4** is disposed, for example, to be exposed on a surface of the small diameter portion **23***b*. The humidity sensor **4** is connected to the circuit board that is included in the circuit module **20** and is connected to the flow rate sensor **3**. The humidity sensor **4** is assembled to the sensor assembly **23** together with the flow rate sensor **3**.

Since air flowing in the bypass passage **7** flows into the recessed portion **30**, a humidity of air flowing in the bypass passage **7**, in other words, a humidity of air flowing in the duct D, can be determined by disposing the humidity sensor **4** in the recessed portion **30**.

Since the recessed portion **30** has the blind-passage shape, air flows in the recessed portion **30** less strongly, and an adhesion of dust to the humidity sensor **4** can be suppressed. That is, a contamination resistance of a physical-quantity measuring sensor (e.g., the humidity sensor **4**) can be improved in the air flow meter **1** having the physical-quantity measuring sensor separately from the flow rate sensor **3**.

Although the physical-quantity measuring sensor is the humidity sensor **4** in the present embodiment, the physical-quantity measuring sensor may be another sensor such as a temperature sensor and a pressure sensor.

In the present embodiment, the humidity sensor **4** is integrally assembled in the sensor assembly **23** having the flow rate sensor **3**. Accordingly, cost can be reduced, and reliability can be improved.

Second Embodiment

An air flow meter **1** of a second embodiment will be described hereafter referring to FIG. **5**. In the second embodiment, features that are different from the first embodiment will be described mainly.

The air flow meter **1** of the second embodiment has physical-quantity measuring sensors separately from the flow rate sensor **3**. For example, the physical-quantity measuring sensors includes a pressure sensor **5** in addition to the humidity sensor **4** as compared to the first embodiment. Similar to the humidity sensor **4**, the pressure sensor **5** is assembled in the sensor assembly **23** to be exposed on the surface of the small diameter portion **23***b*.

The present embodiment can produce the same effects as the first embodiment.

Third Embodiment

An air flow meter **1** of a third embodiment will be described hereafter referring to FIG. **6**. In the third embodiment, features that are different from the first embodiment will be described mainly.

In the third embodiment, the humidity sensor **4** is not assembled in the sensor assembly **23** and is disposed independently from the sensor assembly **23**. That is, the humidity sensor **4** is connected to a circuit board that is different from the circuit board to which the flow rate sensor **3** is connected. For example, the humidity sensor **4** is disposed in an inner surface of the lower hole portion **25***b* and is connected to the circuit board that is different from the circuit board for the flow rate sensor **3**.

The present embodiment can produce the same effects as the first embodiment.

Other Modification

In the above-described embodiments, the part of the insert hole **25** defines the recessed portion **30**. However, as shown in FIG. **7**, the recessed portion **30** may be defined to be recessed from the inner wall surface of the bypass passage **7** at a location distanced from the insert hole **25**. In this case, the physical-quantity measuring sensor (i.e., the humidity sensor **4**) is disposed in the recessed portion **30** separately from the flow rate sensor **3**.

In the above-described embodiments, the bypass passage **7** guides intake air from the intake port **12** to flow to the emitting port **13** after circulating along the bypass passage **7**. Further, the bypass passage **7** has the area **14** in which fluid (i.e., air) flows in a direction that is opposite to the main flow direction. However, the bypass passage **7** is not limited to guide a part of main flow to flow into the bypass passage **7** and to circulate along the bypass passage **7**. The bypass passage **7** may guide air flowing from the intake port **12** to flow in the bypass passage **7** in the main flow direction and to emits the air in the main flow direction as shown in FIG. **8**.

Such changes and modifications are to be understood as being within the scope of the present disclosure as defined by the appended claims.

What is claimed is:

1. An air flow meter comprising:
a housing;
a passage defined in the housing and configured so that a part of air flowing in a duct in a main flow direction flows into the passage,
a flow rate sensor disposed in the housing; and
a physical-quantity measuring sensor configured to measure a physical quantity of air flowing in the duct and disposed separately from the flow rate sensor, wherein
the passage has a straight portion with a surface that extends parallel to the main flow direction,
the housing has a recessed portion communicating with the straight portion of the passage only through a single communication opening,
the single communication opening is through the surface,
the recessed portion is a blind-passage that is recessed in a direction perpendicular to a flow direction of the air flowing in the straight portion, and
the physical-quantity measuring sensor is disposed in the recessed portion to be out of alignment with the straight portion.

2. The air flow meter according to claim **1**, wherein
the flow rate sensor, a circuit board that is connected with the flow rate sensor, and a terminal that connects an external device to the circuit board are modularized to constitute a sensor assembly,
the housing defines a housing space housing the sensor assembly such that the flow rate sensor is exposed in the passage, and
the recessed portion is defined by a part of the housing space.

3. The air flow meter according to claim **1**, wherein
the physical-quantity measuring sensor is connected to a circuit board to which the flow rate sensor is connected, and
the physical-quantity measuring sensor is modularized with the flow rate sensor.

4. The air flow meter according to claim **1**, wherein
the physical-quantity measuring sensor is not assembled in the the flow rate sensor and is disposed independently from the flow rate sensor.

5. The air flow meter according to claim **1**, wherein
the physical-quantity measuring sensor is one of a plurality of physical-quantity measuring sensors.

6. The air flow meter according to claim **1**, wherein the flow direction of air flowing in the straight portion is opposite to the main flow direction.

7. The air flow meter according to claim **1**, further comprising

a main passage in the housing, located in the duct and that extends parallel to the main flow direction,

wherein the main passage is configured so that the part of the air flowing in the duct flows into the main passage, and

wherein the passage is branched from the main passage.

8. The air flow meter according to claim **7**, wherein

the main passage has

an inlet that is open to the passage in the direction perpendicular to the main flow direction, and

an outlet that is open to the duct in the main flow direction,

the passage is branched from the main passage in the inlet, and

air flowing into the passage from the inlet passes through the straight portion and flows out of the passage directly into the duct.

* * * * *