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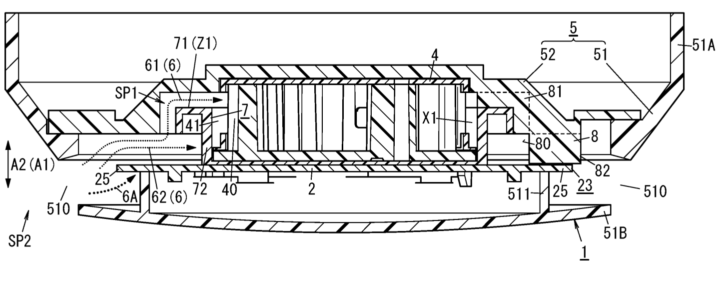
(54) **DETECTOR**

(57) An object of the present disclosure is to reduce the chance that erroneous detection occurs. A sensor 1 includes a smoke detection chamber 4, an opening 510 and a dividing portion Z1. The smoke detection chamber 4 has an inlet port 40 through which smoke flows into the smoke detection chamber 4. The opening 510 connects an external space SP2 and a space SP1 surrounding the smoke detection chamber 4. The dividing portion Z1 divides the gas flow channel 6 such that a first ratio is made higher than a second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port 40 with respect to a first inflow of smoke flowing into the gas flow channel 6 through the opening 510. The second ratio is a ratio of an amount of steam reaching the inlet port 40 with respect to a second inflow of steam flowing into the gas flow channel 6 through the opening 510.

FIG. 1



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Description

Technical Field

[0001] The present disclosure generally relates to sensors, and more particularly relates to a sensor for sensing smoke generated by a fire, for example.

Background Art

[0002] Patent Literature 1 discloses a heat and smoke sensor. The sensor includes a heat sensing means for sensing heat and a smoke sensing unit (smoke detection chamber) for sensing smoke that has flowed into a black box. The heat sensing means includes: a lead wire connected to a circuit board and protruding upward from the circuit board; and a heat sensitive element, such as a thermistor, provided at an upper end of the lead wire. The smoke sensing unit is constituted by the black box, and a light emitting means and a photosensitive means that are disposed inside the black box. The smoke sensing unit senses the smoke by the photosensitive means sensing scattered light generated when light from the light emitting means is scattered by the smoke that has flowed into the black box.

[0003] The sensor may be installed in an environment as often getting into a situation where steam flows into the smoke detection chamber (place such as a dressing room adjacent to a bathroom). In such a case, the sensor disclosed in Patent Literature 1 may erroneously detect, as smoke, the steam.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2012-14330 A

Summary of Invention

[0005] In view of the foregoing background, it is therefore an object of the present disclosure to provide a sensor, which can reduce the chance that erroneous detection occurs.

[0006] A sensor according to an aspect of the present disclosure includes a smoke detection chamber, an opening and a dividing portion. The smoke detection chamber has an inlet port through which smoke flows into the smoke detection chamber. The opening connects an external space and a space surrounding the smoke detection chamber. The dividing portion is disposed in the space surrounding the smoke detection chamber to divide a gas flow channel. The dividing portion is configured to divide the gas flow channel such that a first ratio is made higher than a second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port with respect to a first inflow of smoke flowing into the gas flow channel through the opening. The second ratio is a ratio of an amount of steam reaching the inlet port with respect to a second inflow of steam flowing into the gas flow channel through the opening. The first aspect can reduce the chance that erroneous detection occurs.

Brief Description of Drawings

[0007]

FIG. 1 is a cross-sectional view of a sensor according to a first embodiment;
FIG. 2 is an appearance perspective view of the sensor;
FIG. 3 is an exploded perspective view of the sensor as viewed from above the sensor;
FIG. 4 is an exploded perspective view of the sensor as viewed from below the sensor;
FIG. 5 is a perspective view of the sensor other than a part of an upper cover, as viewed from above the sensor;
FIG. 6 is an exploded perspective view in a state where a cover of a smoke detection chamber is removed, of the sensor illustrated in FIG. 5;
FIG. 7 is a block configuration diagram of the sensor;
FIG. 8 is a perspective view other than an upper cover, of a first variation according to the sensor as viewed from above the first variation;
FIG. 9 is a perspective view other than a part of an upper cover, of a second variation according to the sensor as viewed from above the second variation;
FIG. 10 is a cross-sectional view of a principal part of a third variation according to the sensor;
FIG. 11 is a plan view of a variation of a base according to the sensor;

FIG. 12 is a cross-sectional view of a sensor according to a second embodiment;
FIG. 13 is a perspective view other than a part of an upper cover, of the sensor as viewed from above the sensor;
FIG. 14 is an exploded perspective view of the sensor as viewed from below the sensor;
FIG. 15A is a drawing for explaining responsiveness of the sensor with respect to a taper angle in a slope of the sensor;
FIG. 15B is a drawing for explaining responsiveness of the sensor with respect to a taper angle in an airflow control portion of the sensor;
FIG. 15C is a drawing for explaining responsiveness of the sensor with respect to a thickness in the airflow control portion of the sensor;
FIG. 16 is a cross-sectional view of a principal part of a variation including a protrusion, according to the sensor;
FIG. 17 is a cross-sectional view of a principal part of a variation including an airflow control portion having a taper formed into a curved shape, according to the sensor;
FIG. 18 is a cross-sectional view of a principal part of a variation including a restriction part, according to the sensor; and
FIG. 19 is a cross-sectional view of a principal part of a variation including a dividing portion having a taper as a planar surface, according to the sensor.

Description of Embodiments

(General Overview)

[0008] Hereinafter, the overview of a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to the present disclosure will be described.

[0009] The sensor according to the present disclosure may be implemented as, for example, a fire sensor, which has the capability of detecting (fire) smoke generated by a fire, for example. The sensor according to the present disclosure is a photoelectric type of sensor. In the following description, the sensor according to the present disclosure is assumed to be a scattered light type of sensor, but this is only an example and should not be construed as limiting. The sensor may be a transmitted light type of sensor.

[0010] In the following description, the sensor according to the present disclosure is supposed to be a so-called "combination fire sensor," which has not only a function of detecting smoke but also a function of detecting heat generated by a fire, for example. However, the sensor according to the present disclosure does not have to have the function of detecting heat. As shown in FIG. 2, the sensor according to the present disclosure is installed on an installation surface 100 (e.g., a ceiling surface in the example of the drawing) such as the ceiling surface or a wall surface of a building.

[0011] The sensor according to the present disclosure includes a smoke detection chamber 4, an opening 510 and a dividing portion Z1. The smoke detection chamber 4 has an inlet port 40 through which smoke flows into the smoke detection chamber 4. The opening 510 connects an external space SP2 and a space SP1 surrounding the smoke detection chamber 4. The dividing portion Z1 is disposed in the space SP1 surrounding the smoke detection chamber 4 to divide a gas flow channel 6. The dividing portion Z1 is configured to divide the gas flow channel such that a first ratio is made higher than a second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port 40 with respect to a first inflow of smoke flowing into the gas flow channel 6 through the opening 510. The second ratio is a ratio of an amount of steam reaching the inlet port 40 with respect to a second inflow of steam flowing into the gas flow channel 6 through the opening 510. As shown in FIGS. 3 and 13, the dividing portion Z1 is disposed in the space SP1 surrounding the smoke detection chamber 4 and provided around an entire circumference of the smoke detection chamber 4.

[0012] For example, in the following first embodiment, the dividing portion Z1 is provided such that, in an upside flow channel 61, the first ratio (of the amount of smoke reaching the inlet port 40 with respect to the first inflow) is made higher than the second ratio (of the amount of steam reaching the inlet port 40 with respect to the second inflow), regarding the first inflow of smoke flowing into the gas flow channel 6 through the opening 510 and the second inflow of steam flowing into the gas flow channel 6 through the opening 510. Also, for example, in the following second embodiment, the dividing portion Z1 is provided such that, in a third space SP5, the first ratio (of the amount of smoke reaching the inlet port 40 with respect to the first inflow) is made higher than the second ratio (of the amount of steam reaching the inlet port 40 with respect to the second inflow), regarding the first inflow of smoke flowing into the gas flow channel 6 through the opening 510 and the second inflow of steam flowing into the gas flow channel 6 through the opening 510.

[0013] It can be said that the dividing portion Z1 divides the gas flow channel 6, as long as the "first ratio of the amount of smoke" is made higher than the "second ratio of the amount of steam." The dividing portion Z1 does not have to divide the gas flow channel 6 to completely separate smoke from steam. For example, if a volume flow rate "A" [cm^3/sec] of smoke flows into the opening 510 and a volume flow rate "B" [cm^3/sec] of smoke flows into the inlet port 40, the first ratio is represented as "B/A." If a volume flow rate "A" [cm^3/sec] of steam (i.e., the same volume flow rate as the above smoke) flows into the opening 510 and a volume flow rate "C" [cm^3/sec] of steam flows into the inlet port 40, the second ratio is represented as "C/A." In this case, the dividing portion Z1 divides the gas flow channel 6 such that a condition of "(B/A) > (C/A)" is satisfied, for example.

[0014] Comparing smoke with steam, a smoke particle has a smaller radius than that of a steam particle, and also a smaller weight than that of the steam particle. For this reason, smoke particles have a greater diffusion force and a smaller inertial force, compared with steam particles. Using differences between the smoke and the steam as above, the dividing portion Z1 divides the gas flow channel 6 to a space through which the smoke easily flows and a space through which the steam easily flows.

[0015] According to this configuration, flowing into the smoke detection chamber 4, of the smoke particles, which have the greater diffusion force and the smaller inertial force compared with the steam particles, is promoted by the dividing portion Z1, but the steam particles are suppressed from flowing into the smoke detection chamber 4. That is to say, gas including the smoke is caused to more stably flow into the smoke detection chamber 4 from the inlet port 40 by the dividing portion Z1. As a result, the sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to the disclosure can reduce the chance that erroneous detection occurs.

(First Embodiment)

(1) Overview

[0016] As shown in FIG. 1, a sensor 1 according to the present embodiment includes a smoke detection chamber 4 and a dividing portion Z1. The dividing portion Z1 includes a branching part 71.

[0017] The smoke detection chamber 4 has an inlet port 40 through which smoke flows into the smoke detection chamber 4. The branching part 71 is disposed around the smoke detection chamber 4. The branching part 71 is configured to divide the space SP1 surrounding the smoke detection chamber 4 into two areas in a separation direction A1 including a component of a vertical direction A2 so as to branch (divide) the gas flow channel 6 into an upside flow channel 61 and a downside flow channel 62.

[0018] The branching part 71 is further configured to cause smoke, which has flowed through the upside flow channel 61, of the upside flow channel 61 and the downside flow channel 62, to flow into the smoke detection chamber 4 from the inlet port 40. That is to say, the branching part 71 of the dividing portion Z1 branches (divides) the gas flow channel 6 into the upside flow channel 61 and the downside flow channel 62. In the upside flow channel 61, the first ratio (of the amount of smoke reaching the inlet port 40 with respect to the first inflow) is made higher than the second ratio (of the amount of steam reaching the inlet port 40 with respect to the second inflow).

[0019] According to this configuration, while the smoke particles (easily moving upward) flow through the upside flow channel 61, the steam particles having larger mass than that of the smoke particles easily flow through the downside flow channel 62 rather than the upside flow channel 61. That is to say, only the smoke is caused to flow into the smoke detection chamber 4 from the inlet port 40 at high possibility by the branching part 71. As a result, the sensor 1 can reduce the chance that erroneous detection occurs.

[0020] In the present embodiment, the sensor 1 further includes at least one airflow control wall 8 (refer to FIG. 5) (two in this embodiment) in addition to the smoke detection chamber 4. The smoke detection chamber 4 has an inlet port 40 through which smoke flows into the smoke detection chamber 4. The airflow control walls 8 are disposed around the smoke detection chamber 4. The airflow control walls 8 control the airflow so as to make less variation in the inflow property of smoke with respect to the smoke detection chamber 4 in a circumferential direction A3 of the smoke detection chamber 4. The "variation in the inflow property of smoke is less" mentioned herein means that the variation in the amount of the smoke flowing into the smoke detection chamber 4 is less, even if the smoke enters the sensor 1 (through the opening 510) from any direction of 360° around the sensor 1, when the sensor 1 is viewed along the vertical direction.

[0021] According to this configuration, the airflow control walls 8 control the airflow so as to make less variation in the inflow property of smoke with respect to the smoke detection chamber 4. The sensor 1 therefore can improve the inflow property of smoke with respect to the smoke detection chamber 4.

(2) Detail

(2.1) Overall Configuration

[0022] Next, an overall configuration of the sensor 1 according to the present embodiment will be described in detail. The sensor 1 is implemented as a combination fire sensor for detecting both heat and smoke as described above.

[0023] Hereinafter, an upward/downward direction of the sensor 1 is defined based on an up-down arrow illustrated in FIG. 2, which shows a situation where the sensor 1 is installed on an installation surface 100 (ceiling surface). Note that this arrow is just shown there as an assistant to description and is an insubstantial one. It should also be noted that this direction does not define the direction in which the sensor 1 should be used.

[0024] The sensor 1 includes the smoke detection chamber 4 (smoke detection unit) described above. As shown in FIGS. 1 and 3 to 6, the sensor 1 further includes a base 2, a housing 5 and a flow channel forming member 7. As shown in FIG. 7, the sensor 1 further includes a heat detection unit 3, a control unit 9 and a display unit 10. The sensor 1 further includes a disklike attachment base to be fixed to the installation surface 100 by screws or any other means. The sensor 1 may be installed on the installation surface 100 by an attachment part provided on an upper surface of the housing 5 being attached removably to the attachment base.

[0025] The sensor 1 further includes a communications unit 11 (refer to FIG. 7) for transmitting, on detecting a fire, a signal serving as an alert to the presence of the fire to an external alarm device or any other device, and receiving a signal from the alarm device, for example.

[0026] The sensor 1 may be supplied with power from either a commercial power supply or a battery provided inside the housing 5, whichever is appropriate.

(2.2) Housing

[0027] The housing 5 houses the base 2, the heat detection unit 3, the smoke detection chamber 4, the control unit 9, the display unit 10, the communications unit 11, and other circuit modules therein. In addition, the housing 5 also supports the display unit 10 such that one surface of a guide portion of the display unit 10 is exposed to the external space.

[0028] The housing 5 is made of a synthetic resin and may be made of flame-retardantABS resin, for example. The housing 5 is formed in the shape of a circular cylinder, which is generally compressed in the upward/downward direction. As shown in FIGS. 3 and 5, the housing 5 includes: a circular cylindrical lower cover 51 (front cover), of which one surface (e.g., an upper surface in the example illustrated in FIGS. 3 and 5) is open; and a disklike upper cover 52 (back cover). The housing 5 is formed by attaching the upper cover 52 into the lower cover 51 such that the upper cover 52 is inserted through the opened surface of the lower cover 51. The upper cover 52 is disposed to cover the smoke detection chamber 4 from above the smoke detection chamber 4. The lower cover 51 is disposed under the base 2.

[0029] The housing 5 includes: a gas flow channel 6 provided in the space SP1 inside the housing 5, through which gas flows; and one or more openings 510 (side hole) connecting the gas flow channel 6 and the external space SP2 (six openings 510 in this embodiment). In this embodiment, the openings 510 are provided in the lower cover 51. In other words, the lower cover 51 has the opening(s) 510 connecting the external space SP2 and the space SP1 surrounding the smoke detection chamber 4.

[0030] More specifically, as shown in FIGS. 2 and 3, the lower cover 51 includes: a compressed circular cylindrical body 51A, of which the upper and lower ends are opened; a disklike base portion 51B provided under the circular cylindrical body 51A; and a plurality of (e.g., six) beams 51C that connect the circular cylindrical body 51A to the base portion 51B. The circular cylindrical body 51A, the base portion 51B, and the six beams 51C are formed integrally with each other. The six beams 51C are arranged at nearly regular intervals along the circumference of the peripheral edge portion of the base portion 51B and protrude from the peripheral edge portion toward the opened lower edge portion of the circular cylindrical body 51A. These six beams 51C are provided to keep a predetermined distance between the circular cylindrical body 51A and the base portion 51B. The six openings 510 are provided through the peripheral wall of the lower cover 51 with such a configuration and arranged at nearly regular intervals along a circumferential direction of the peripheral wall (corresponding to a circumferential direction A4 of the sensor 1).

[0031] Each of these openings 510 is a generally rectangular through hole, which radially penetrates through the peripheral wall of the lower cover 51 and serves as a hole connecting the gas flow channel 6 to the external space SP2.

[0032] The base portion 51B includes, on the upper surface thereof, a positioning structure for positioning the base 2. In this embodiment, a tubular portion 511 is provided as the positioning structure (refer to FIGS. 1 and 3). In other words, the sensor 1 according to the present embodiment further includes the tubular portion 511 disposed to cover a lower surface (second surface 22) of the base 2. The tubular portion 511 is protruded in a cylindrical shape from the upper surface of the base portion 51B. The tubular portion 511 has an upper end surface that is in contact with the lower surface of the base 2.

[0033] In addition, the base portion 51B of the lower cover 51 further has a pair of ports (not shown in FIG. 2), through each of which one surface (i.e., lower surface) of the guide portion of the display unit 10 is exposed to the external space SP2. This allows light emitted from a pair of light sources 10A of the display unit 10 (refer to FIG. 4) to be guided out of the housing 5 through the pair of guide portions.

[0034] The upper cover 52 has a plurality of fitting holes, into which fitted are a plurality of connection pieces of the attachment part fixed on the base 2. The plurality of connection pieces are electrically connected to a circuit module provided on the base 2. The plurality of connection pieces are inserted to the point that their respective tips protrude sufficiently from the back surface of the upper cover 52. The plurality of connection pieces may be mechanically and electrically connected to contact portions of the attachment base fixed onto the installation surface 100. That is to say, the attachment part is used to not only mechanically connect this sensor 1 to the attachment base but also electrically connect the sensor 1 to electric cables (including power cables and signal cables) provided on the back of the ceiling and position the base 2 with good stability with respect to the upper cover 52.

[0035] In addition, the upper cover 52 further has a housing recess 521, which is provided on one surface thereof facing the base 2 (i.e., the lower surface) to house an upper part of the smoke detection chamber 4 mounted on the base 2 (refer to FIG. 4). The housing recess 521 is provided by the whole central part of the upper cover 52 being protruded upward. The housing recess 521 allows the smoke detection chamber 4 to be positioned with good stability.

[0036] As shown in FIG. 4, the sensor 1 in this embodiment further includes a pair of airflow control walls 8. As one example, the airflow control walls 8 in this embodiment are formed as parts of the upper cover 52. The pair of airflow control walls 8 are disposed outside of the housing recess 521 on one surface (i.e., the lower surface) facing the base 2, of the upper cover 52. The pair of airflow control walls 8 are disposed around the smoke detection chamber 4 and control the air flow so as to make less variation in the inflow property of smoke with respect to the smoke detection chamber 4 in the circumferential direction A3 of the smoke detection chamber 4. The airflow control walls 8 will be described later in detail.

(2.3) Base

[0037] The base 2 is configured such that the smoke detection chamber 4 is mounted thereon. As one example, the base 2 in this embodiment is a circuit board. The base 2 is, for example, a single printed wiring board where patterned conductor wirings are formed. As shown in FIGS. 3 and 4, the base 2 has a pair of fitting holes 27 that penetrate through the base 2 in the thickness direction. The smoke detection chamber 4 includes a body 4B having a pair of fitting pieces 42 (refer to FIG. 4). The smoke detection chamber 4 is attached to a first surface 21 (upper surface) of the base 2 by the pair of fitting pieces 42 being respectively inserted into and hooked by the pair of fitting holes 27. Note that the flow channel forming member 7 is held to be sandwiched by the smoke detection chamber 4 and the base 2 from upward and downward

[0038] On the base 2, mounted are, not only the smoke detection chamber 4 but also the heat detection unit 3, the control unit 9, the display unit 10, the communications unit 11, and other circuit modules. Examples of the other circuit modules include: a lighting circuit for turning ON the light sources 10A of the display unit 10 and an optical element 401 (refer to FIGS. 6 and 7) of the smoke detection chamber 4; and a power supply circuit for generating operating power for various types of circuits based on the power supplied from a commercial power supply, for example.

[0039] As shown in FIGS. 3 and 4, the base 2 is formed in a generally circular shape as a whole. In the present embodiment, the heat detection unit 3 includes one or more (six in the example of FIG. 5) heat sensitive elements 30 that are disposed on an outer peripheral part 23 of the base 2. The six heat sensitive elements 30 are surface-mounted on the first surface 21 (upper surface) of the base 2. As one example, the smoke detection chamber 4 in this embodiment is also disposed on the first surface 21 of the base 2. In the following description, the other surface, opposite from the first surface 21, of the base 2 will be hereinafter sometimes referred to as a "second surface 22 (lower surface)." As shown in FIG. 4, the light sources 10A of the display unit 10 are mounted on the second surface 22 of the base 2.

[0040] Of the first surface 21 and the second surface 22, the first surface 21 corresponds to a surface located closer to the installation surface 100. Thus, it can be said that the heat sensitive elements 30 and the smoke detection chamber 4 are all arranged on the surface, located closer to the installation surface 100, of the base 2.

[0041] Each of electronic components, which constitute the control unit 9 and the circuit modules, may be mounted on the first surface 21 or the second surface 22 of the base 2. The electronic components, which constitute the control unit 9 and the circuit modules, do not have to be mounted on only the base 2. For example, another mounting board may be additionally disposed near the base 2, and at least one of the electronic components may be mounted on the other mounting board.

[0042] Next, the structure of the base 2 will be described in detail. As shown in FIG. 5, the base 2 includes: a circular-shaped main body 20 (portion inside a dashed line); and a plurality of (e.g., twelve in the example illustrated in FIG. 5) extended portions which are extended away from the center of the main body 20 on the periphery of the main body 20. The smoke detection chamber 4 is disposed on the center of the upper surface of the main body 20.

[0043] The twelve extended portions are constituted by six protruded edges 25 and six tongue parts 26. The outer peripheral part 23 of the base 2 described above corresponds to the six protruded edges 25 and the six tongue parts 26.

[0044] Each of the six tongue parts 26 is a part on which a corresponding one of the six heat sensitive elements 30 is mounted. Each of the six tongue parts 26 has an upper surface and a lower surface that are respectively flush and continued with the upper surface and the lower surface of the main body 20. Each of the six tongue parts 26 is protruded as a thin strip shape from the main body 20, when viewed along the upward/downward direction, and its tip is formed into a semicircular shape. The six tongue parts 26 are arranged at nearly regular intervals along the circumferential direction of the main body 20 so as to divide the outer peripheral part 23 of the base 2 into nearly six equal parts. Each of the heat sensitive elements 30 is mounted on the upper surface near the tip, of a corresponding tongue part 26. Each of the six tongue parts 26 has a through hole 260 that is disposed in a region inside a corresponding heat sensitive element 30 and opened in a rectangular shape. The respective through holes 260 are provided adjacent to the heat sensitive elements 30. Providing the through hole 260 adjacent to each heat sensitive element 30 allows the area of the base 2 to be reduced around the heat sensitive element 30, thus reducing the chance of the temperature of the heat of the heat sensitive element 30 being lowered by being transferred through the base 2, or the chance of heat generated by the other circuit components mounted on the main body 20 affecting the heat sensitive element 30. That is to say, the through hole 260 improves the thermal insulation properties. The aperture area of the through hole 260 is suitably larger than the surface area of the heat sensitive element 30 (e.g., the surface area as viewed from over the base 2).

[0045] Each of the six protruded edges 25 has an upper surface and a lower surface that are respectively flush and continued with the upper surface and the lower surface of the main body 20. Each of the six protruded edges 25 has a strip shape curved along an arc of a virtual circle around a central axis of the main body 20, when viewed along the upward/downward direction. The six protruded edges 25 are arranged along the circumferential direction of the main body 20. The six protruded edges 25 are arranged such that a corresponding one of the six tongue parts 26 is disposed between two protruded edges 25 adjacent to each other. In other words, the six tongue parts 26 and the six protruded edges 25 are arranged alternately one by one along the circumferential direction of the main body 20.

[0046] As shown in FIG. 1, each protruded edge 25 in the present embodiment is configured to be protruded outward from the tubular portion 511. In other words, the projection area of the main body 20 when viewed along the upward/downward direction is almost equal to an area of the tubular portion 511, and the six protruded edges 25 stick out of the tubular portion 511. Note that a protruded dimension of each tongue part 26 with respect to the main body 20 is slightly greater than a protruded dimension of each protruded edge 25 with respect to the main body 20.

[0047] The base 2 further has a recess 24 (refer to FIG. 5) in the outer peripheral part 23, which is disposed around a region at which each heat sensitive element 30 is disposed and recessed inward. In this embodiment, twelve recesses 24 in total are provided such that one pair of recesses 24 correspond to each of the six tongue parts 26. More specifically, two recesses 24 paired are respectively disposed in both sides in the circumferential direction of the main body 20, of each tongue part 26 on which a corresponding heat sensitive element 30 is mounted.

[0048] Accordingly, each tongue part 26 is disposed between two protruded edges 25 adjacent to each other so as to form a gap between the tongue part 26 and each of the two protruded edges 25. This allows hot air generated by a fire to be more efficiently guided to the heat sensitive elements 30 mounted on the tongue parts 26 through the recesses 24. That is to say, the heat flow can be improved. Furthermore, providing the recesses 24 can reduce the chance that the temperature of the heat of the heat sensitive elements 30 is lowered by being transferred through the base 2, or the chance that heat generated by the other circuit components mounted on the main body 20 affects the heat sensitive elements 30 on the tongue parts 26 through the protruded edges 25.

[0049] Thus, the base 2 in the present embodiment has, for example, a six-fold symmetric shape, which makes the base 2 symmetric when the base 2 is rotated 60 degrees around its center.

(2.4) Heat detection unit and smoke detection unit

[0050] As described above, the heat detection unit 3 includes the six heat sensitive elements 30 which are mounted on the first surface 21 of the base 2 (and only one of which is shown in FIG. 7). The number of the heat sensitive elements 30 provided is not limited to any particular number but may also be one. Nevertheless, at least two heat sensitive elements 30 are suitably provided. In addition, each heat sensitive element 30 is implemented as a chip thermistor for detecting the heat of gas that has flowed in through the opening 510 and is surface-mounted on the base 2. The respective heat sensitive elements 30 are arranged such that each of the heat sensitive elements 30 faces an associated one of the six different openings 510.

[0051] The heat detection unit 3 is electrically connected, via patterned wiring formed on the base 2 and other members, to the control unit 9. Each heat sensitive element 30 outputs an electrical signal (detection signal) to the control unit 9. In other words, the control unit 9 monitors, based on the electrical signals provided by the respective heat sensitive elements 30, the resistance values, which may vary as the temperature increases, of the respective heat sensitive elements 30.

[0052] Optionally, the heat detection unit 3 may include not only the heat sensitive elements 30 but also an amplifier circuit for amplifying the electrical signals provided by the heat sensitive elements 30, a converter circuit for performing analog-to-digital conversion on the electrical signals, and other circuits as well. Alternatively, the amplification and conversion may be performed by the circuit modules.

[0053] The smoke detection chamber 4 is arranged in a central area of the internal space of the housing 5 and configured to detect smoke. Specifically, the smoke detection chamber 4 is arranged on the upper surface of the main body 20 of the base 2 and has an upper part thereof housed in the housing recess 521 of the upper cover 52. The smoke detection chamber 4 may be implemented as a photoelectric type of sensor for detecting smoke, for example (in particular, a scattered light type of sensor).

[0054] As shown in FIGS. 6 and 7, the smoke detection chamber 4 includes an optical element 401 for emitting light, a photosensitive element 402 for receiving the light emitted from the optical element 401, and a labyrinth structure 403.

The optical element 401 may be implemented as a light-emitting diode (LED), for example. The photosensitive element 402 may be implemented as a photodiode, for example. The labyrinth structure 403 is formed inside a housing having a compressed, generally circular cylindrical shell.

[0055] The smoke detection chamber 4 has a housing configured by a cover 4A and a body 4B being assembled with each other. As shown in FIG. 6, the cover 4A has a compressed, generally circular cylindrical shell, of which lower surface is open. The cover 4A has a plurality of inlet ports 40 disposed in an outer peripheral surface of the cover 4A to cause gas to flow into the labyrinth structure 403. That is to say, the smoke by a fire flows into the labyrinth structure 403 through the plurality of inlet ports 40. Each of the plurality of inlet ports 40 has a generally rectangular shaped opening when viewed from the front thereof. The plurality of inlet ports 40 are arranged along the circumferential direction A3 of the smoke detection chamber 4. Not that the circumferential direction A3 of the smoke detection chamber 4 in the present embodiment corresponds to the circumferential direction A4 of the sensor 1.

[0056] The body 4B is formed into a generally disk shape and has: a structure disposed on the upper surface of the body 4B and suppressing natural light from entering the inside; and a structure holding the optical element 401 and the photosensitive element 402. The body 4B further has a pair of fitting pieces 42 (refer to FIG. 4) protruded downward from a lower edge of the body 4B. The pair of fitting pieces 42 are respectively inserted into a pair of insertion holes 74 provided in the flow channel forming member 7 and then respectively inserted into and hooked by the pair of fitting holes 27 of the base 2, thereby the smoke detection chamber 4 being attached to the base 2 such that the flow channel forming member 7 is interposed between the base 2 and the smoke detection chamber 4.

[0057] The optical element 401 and the photosensitive element 402 are arranged in the labyrinth structure 403 to avoid facing each other. In other words, the optical element 401 and the photosensitive element 402 are arranged such that the photosensitive plane of the photosensitive element 402 is off an optical axis of emission light emitted from the optical element 401.

[0058] At the outbreak of a fire, for example, smoke may enter the housing 5 through the openings 510 of the housing 5 and be introduced into the labyrinth structure 403 through the inlet port(s) 40. If no smoke is present in the labyrinth structure 403, the emission light emitted from the optical element 401 hardly reaches the photosensitive plane of the photosensitive element 402. On the other hand, if there is any smoke in the labyrinth structure 403, then the emission light emitted from the optical element 401 is scattered by the smoke and part of the scattered light eventually impinges on the photosensitive plane of the photosensitive element 402. That is to say, the smoke detection chamber 4 is configured to have the emission light, which has been emitted from the optical element 401 and scattered by the smoke, received at the photosensitive element 402.

[0059] The photosensitive element 402 of the smoke detection chamber 4 is electrically connected to the control unit 9. The smoke detection chamber 4 transmits an electrical signal (detection signal), having a voltage level corresponding to the quantity of light received at the photosensitive element 402, to the control unit 9. In response, the control unit 9 converts the quantity of the light, represented by the detection signal provided by the smoke detection chamber 4, into a smoke concentration, thereby determining whether or not a fire is actually present. Optionally, the control unit 9 may use the quantity of the light as it is to make a decision based on a threshold value. Alternatively, the smoke detection chamber 4 may convert the quantity of light received at the photosensitive element 402 into a smoke concentration and then transmit a detection signal, having a voltage level corresponding to the smoke concentration, to the control unit 9.

[0060] The smoke detection chamber 4 may further include an amplifier circuit for amplifying the electrical signal provided by the photosensitive element 402, a converter circuit for performing an analog-to-digital conversion on the electrical signal, and other circuits. Alternatively, the amplification and conversion may be performed by the circuit modules. Also, the number of the optical element 401 for use to detect smoke does not have to be one but may also be plural.

(2.5) Display Unit

[0061] The display unit 10 includes a pair of light sources 10A and a pair of guide portions. Each of the light sources 10A may be implemented as a package LED, in which at least one LED chip is mounted at the center of a mounting surface of a flat-plate mount substrate, for example. Each light source 10A is mounted on the base 2 as described above. Each guide portion is a portion having a light-transmitting property. Each guide portion has an incident surface which faces an associated light source 10A on the base 2 and on which the light emitted from the light source 10A is incident. Each guide portion also has an emergent surface, through which the light incident from the incident surface emerges out of the guide portion. The emergent surface of each guide portion is exposed through an associated port of the lower cover 51.

[0062] The display unit 10 serves as an indicating lamp for notifying a person, who is located outside of the sensor 1, of the operating status of the sensor 1. In a normal state (i.e., while the sensor 1 is monitoring to see if there is any fire), the lighting circuit of the circuit module turns the light sources 10A OFF under the control of the control unit 9. When a decision is made that a fire should be present, the lighting circuit of the circuit module starts flashing or turning ON the light sources 10A under the control of the control unit 9. Note that in FIG. 7, illustration of the lighting circuit between the control unit 9 and the display unit 10 is omitted.

(2.6) Control Unit

[0063] The control unit 9 is implemented as a computer system including one or more processors (microprocessors) and one or more memories. That is to say, the one or more processors perform the function of the control unit 9 by executing one or more programs (applications) stored in the one or more memories. In this embodiment, the program is stored in advance in the memory of the control unit 9. However, this is only an example and should not be construed as limiting. The program may also be downloaded via a telecommunications line such as the Internet or distributed after having been stored in a non-transitory storage medium such as a memory card.

[0064] The control unit 9 is configured to control the communications unit 11 and circuit modules (including the lighting circuit and the power supply circuit).

[0065] In addition, the control unit 9 is also configured to receive detection signals from the heat detection unit 3 and the smoke detection chamber 4 to determine whether or not a fire is actually present. Specifically, the control unit 9 monitors the respective detection signals provided by the six heat sensitive elements 30 of the heat detection unit 3 on an individual basis, and decides, on finding at least one heat sensitive element 30, of which the signal level (corresponding to a resistance value) included in the detection signal is greater than (or less than) the threshold value, that a fire should be present. In addition, the control unit 9 also monitors the detection signal provided by the smoke detection chamber 4 and decides, on finding the signal level (corresponding to the quantity of light received at the photosensitive element 402 or a smoke concentration) included in the detection signal greater than a threshold value, that a fire should be present.

[0066] On deciding, based on detection of either heat or smoke, that a fire should be present, the control unit 9 makes the communications unit 11 transmit a signal alerting a person to the presence of the fire to a receiver, fire alarm devices, and other devices of an automatic fire alarm system. The communications unit 11 may be implemented as a communications interface for communicating, via cables, for example, with the receiver, the fire alarm devices, and other devices. The communications unit 11 is connected to communicate with the receiver, the fire alarm devices, and other devices via the connection pieces of the attachment part, the connector portion of the attachment base, and the signal cables provided on the back of the ceiling. In addition, on deciding that the fire should be present, the control unit 9 also outputs, to the lighting circuit of the circuit modules, a control signal to flash or turn ON the light sources 10A of the display unit 10 (indicating lamp).

(2.7) Flow Channel Forming Member

[0067] The flow channel forming member 7 in the present embodiment is made of a synthetic resin and may be made of flame-retardant ABS resin, for example. The flow channel forming member 7 has a compressed, generally circular cylindrical shell, of which upper surface is opened. Specifically, as shown in FIGS. 3 and 4, the flow channel forming member 7 includes a base part 70, the branching part 71 (dividing portion Z1) and a blocking part 72.

[0068] The base part 70 has a disk shape. The base part 70 has the pair of insertion holes 74 that penetrate through the base part 70 in the thickness direction. As described above, the pair of fitting pieces 42 of the smoke detection chamber 4 may be respectively inserted into the pair of insertion holes 74.

[0069] The blocking part 72 is a circular cylindrical shaped part, which is continuously formed to be protruded upward from an outer peripheral edge of the base part 70. The smoke detection chamber 4 is housed in a recess 75 (refer to FIG. 3) surrounded by the base part 70 and the blocking part 72, while the smoke detection chamber 4 is attached to the base 2 such that the smoke detection chamber 4 and the base 2 sandwich the flow channel forming member 7 therebetween. While the smoke detection chamber 4 is housed in the recess 75, the peripheral wall 41 of the smoke detection chamber 4 is generally covered with the blocking part 72 to leave a predetermined space X1 (refer to FIGS. 1 and 6) from the blocking part 72.

[0070] The branching part 71 is a generally annular shaped part, which is continuously formed from an upper edge of the blocking part 72. Specifically, the branching part 71 is provided to extend outward from the upper edge of the blocking part 72 in the radial direction of the blocking part 72 and be further protruded downward. As a result, the flow channel forming member 7 is provided such that its upper edge has a "fold-back shape," as a whole. The branching part 71 is provided over the entire of the upper edge of the blocking part 72 in the circumferential direction thereof. While the smoke detection chamber 4 is housed in the recess 75, the branching part 71 is disposed around the smoke detection chamber 4.

[0071] The branching part 71 in the present embodiment is configured to divide the space SP1 surrounding the smoke detection chamber 4 into two areas in a separation direction A1 including a component of a vertical direction A2 so as to branch (divide) the gas flow channel 6 into an upside flow channel 61 and a downside flow channel 62. The branching part 71 (dividing portion Z1) is further configured to cause smoke, which has flowed through the upside flow channel 61, to flow into the smoke detection chamber 4 from the inlet port 40. In this embodiment, the space SP1 is divided into two areas generally in the upward/downward direction by the branching part 71. That is to say, the separation direction A1 generally corresponds to the vertical direction A2. However, the separation direction A1 may intersect with the vertical direction A2 as long as the separation direction A1 includes the component of the vertical direction A2.

[0072] Specifically, the space SP1 is surrounded by the upper cover 52, the base 2 and the smoke detection chamber 4. The upside flow channel 61 is a flow channel surrounded by the upper cover 52 and the branching part 71 and has a shape like a crank in the cross-sectional view of FIG. 1. In other words, the upper cover 52 is disposed to form a part of the upside flow channel 61. This can contribute to reducing the number of components of the sensor 1, compared with a case that another member forming the upside flow channel 61 is provided separately from the upper cover 52. Furthermore, this can contribute to downsizing the sensor 1 (in particular, reducing the thickness of the sensor 1).

[0073] The downside flow channel 62 is disposed below the upside flow channel 61 and is a flow channel linearly in the cross-sectional view along the first surface 21 (upper surface) of the base 2. In FIG. 1, the upside flow channel 61 and the downside flow channel 62 are schematically illustrated with arrows to make it easier to understand a direction in which gas flows. In FIG. 1, only the upside flow channel 61 and the downside flow channel 62 on the left side of the smoke detection chamber 4 are illustrated with the arrows, but they are actually provided around an entire circumference of the smoke detection chamber 4 in the circumferential direction A3.

[0074] The mass of a steam particle is larger than that of a smoke particle. Since the branching part 71 (dividing portion Z1) is provided, smoke particles (more easily moving upward, compared with steam particles) flow dominantly through the upside flow channel 61 rather than the downside flow channel 62, after entering the sensor 1 from the opening(s) 510. Therefore, the smoke particles more easily get over the branching part 71 (dividing portion Z1) and flow into the smoke detection chamber 4 from the inlet port 40 on the back side of the blocking part 72. On the other hand, the steam particles (each of which has larger mass than that of the smoke particle) flow dominantly through the downside flow channel 62 rather than the upside flow channel 61, after entering the sensor 1 from the opening(s) 510. That is to say, the branching part 71 (dividing portion Z1) can increase the chance that only the smoke particles are caused to flow into the smoke detection chamber 4 from the inlet port 40. As a result, the sensor 1 can reduce the chance that erroneous detection occurs (e.g., the chance of erroneously detecting presence of the steam, as presence of the smoke by a fire).

[0075] In particular, the space SP1 surrounding the smoke detection chamber 4 is divided into two areas in the sensor 1, which can reduce the chance that the erroneous detection occurs, while keeping the appearance size of the sensor 1 relatively thinned in the upward/downward direction.

[0076] As shown in FIG. 1, the blocking part 72 is disposed between the downside flow channel 62 and the smoke detection chamber 4 and configured to block steam flowing through the downside flow channel 62 from flowing into the smoke detection chamber 4. Therefore, the steam, which flows dominantly through the downside flow channel 62 rather than the upside flow channel 61 by the branching part 71 being provided, collides with the blocking part 72 at a high probability. As a result, the steam is suppressed from flowing into the smoke detection chamber 4, and therefore the sensor 1 can further suppress occurrence of the erroneous detection. In particular, the upper edge of the flow channel forming member 7 has the "fold-back shape" as described above, which can suppress the chance that the steam is moved upward by a reaction on colliding with the blocking part 72 to get over the blocking part 72 and then reaches the inlet port 40 on the back side of the blocking part 72.

[0077] In addition, the base 2 in the present embodiment has the (six) protruded edges 25 protruded to stick out of the tubular portion 511, as described above. Therefore, it can suppress the chance that, even if part of the steam, which has entered the sensor 1 from the opening 510, flows through a flow channel 6A schematically illustrated with an arrow in FIG. 1, the part is moved upward by a reaction on colliding with the tubular portion 511 to get over the base 2. In short, the protruded edges 25 can block the steam from being moved upward.

[0078] Furthermore, the protruded edges 25 are protruded so as to make a channel length of the downside flow channel 62 longer. As the channel length of the downside flow channel 62 is made longer, the straight traveling of the steam particle (having larger mass than that of the smoke particle) by inertia can be kept more stable. Providing the protruded edges 25 at the base 2 can therefore ensure the channel length of the downside flow channel 62 longer and further reduce a ratio of the steam moving upward in the middle and toward the upside flow channel 61.

[0079] Thus, the steam moving upward is blocked by the protruded edges 25 and furthermore the straight traveling of the steam is kept stable, which can reduce the chance that the steam flows through the upside flow channel 61.

[0080] In the present embodiment, the outer peripheral part 23 of the base 2 (corresponding to the protruded edges 25 and the tongue parts 26 in this embodiment) is disposed not to be protruded to the external space SP2 from the opening 510, when viewed from front of the lower cover 51, which can reduce the chance that the smoke is prevented from entering the sensor 1 through the opening 510 by the outer peripheral part 23 of the base 2.

(2.8) Airflow Control Wall

[0081] The peripheral wall 41 of the smoke detection chamber 4 in the present embodiment has a region where no inlet port 40 for smoke is provided and therefore smoke hardly flows into the smoke detection chamber 4. In this embodiment, the cover 4A of the smoke detection chamber 4 has a facing wall 405 (refer to FIG. 6), and the facing wall 405 corresponds to the region where the smoke hardly flows into the smoke detection chamber 4. The facing wall 405 faces an outer surface of a holding block 404 (refer to FIG. 6) of the body 4B holding the optical element 401, while the cover 4A is assembled to the body 4B. In other words, the holding block 404 holding the optical element 401 is disposed closer to an outer periphery of the body 4B in the sensor 1 of the present embodiment, and for this reason, the smoke detection chamber 4 has a structure to make it hard to dispose an inlet port 40 on the side of the outer surface of the holding block 404.

[0082] In the following description, of the peripheral wall 41 of the smoke detection chamber 4, a region in which the inlet ports 40 are provided is sometimes referred to as a first region 411, and a region in which no inlet port 40 is provided is sometimes referred to as a second region 412 (refer to FIG. 5). That is to say, the peripheral wall 41 includes the first region 411 and the second region 412. The facing wall 405 corresponds to the second region 412.

[0083] The smoke detection chamber 4 in the present embodiment includes two airflow control walls 8 (i.e., a pair of airflow control walls 8) (refer to FIGS. 5 and 6) as described above. Each of the airflow control walls 8 is a part having a generally rectangular plate shape. Each of the airflow control walls 8 extends, from the peripheral wall 41 of the smoke detection chamber 4, to a position of an extent in which its end slightly sticks out of the outer edge of the protruded edge 25 of the base 2, when viewed along the upward/downward direction. Each of the airflow control walls 8 is disposed such that its thickness direction is parallel to a tangential direction of the base 2 having a generally disk shape. In FIGS. 5 and 6, only the two airflow control walls 8, of the upper cover 52, are shown in cross section.

[0084] As shown in FIG. 1, each of the airflow control walls 8 includes a first portion 81 having an L-shape and a second portion 82 having a rectangular shape, when viewed along the thickness direction. The first portion 81 is disposed to be in contact with an upper surface and an outer peripheral surface of the branching part 71 of the flow channel forming member 7. The second portion 82 is disposed such that an inside corner of an upper end thereof is generally aligned with an outside corner of a lower end of the L-shaped first portion 81. The second portion 82 is disposed such that a lower end thereof is in contact with the first surface 21 of the base 2 (principally the upper surface of the protruded edge 25).

[0085] Each of the airflow control walls 8 has a groove 80 in a position corresponding to the downside flow channel 62. The groove 80 is provided for escaping steam flowing dominantly through the downside flow channel 62. The groove 80 is configured by the lower end of the first portion 81 and the inside part of the second portion 82. While the airflow control walls 8 are in contact with the base 2 and the flow channel forming member 7, each groove 80 is provided as an opening with a generally rectangular shape, surrounded by the first portion 81, the second portion 82, the base 2 and the flow channel forming member 7, when viewed along the circumferential direction A3, as shown in FIG. 1.

[0086] As shown in FIGS. 5 and 6, the two airflow control walls 8 of the present embodiment are disposed such that the second region 412 is interposed therebetween in the circumferential direction A3 of the peripheral wall 41. In this embodiment, as shown in FIG. 5, an angle range of the second region 412 (facing wall 405) in the circumferential direction A3, centered on a central point P1 of the smoke detection chamber 4, corresponds to a first angle $\theta 1$, when viewed from above the smoke detection chamber 4. The first angle $\theta 1$ is about 40 degrees in this embodiment. Also as shown in FIG. 5, an angle range between the two airflow control walls 8 in the circumferential direction A3, centered on the central point P1, corresponds to a second angle $\theta 2$. The second angle $\theta 2$ is about 120 degrees in this embodiment. That is to say, the second angle $\theta 2$ is about three times the first angle $\theta 1$, for example. In other words, each of the two airflow control walls 8 is disposed at a prescribed angular interval (about 40 degrees in this embodiment) from the second region 412 in the circumferential direction A3. Note that numerical values relating to those angles are only one examples and should not be construed as limiting.

[0087] Thus, each airflow control wall 8, disposed around the smoke detection chamber 4, controls airflow so as to make less variation in the inflow property of smoke with respect to the smoke detection chamber 4 in the circumferential direction A3. Specifically, even if smoke, which has traveled toward the second region 412 from the external space SP2, collides with the second region 412 and flows along the circumferential direction A3 while being repelled, each of the airflow control walls 8 can guide the smoke to the inlet ports 40 disposed near the airflow control wall 8 by the smoke colliding with the airflow control wall 8 (refer to airflow B1 shown with arrows in FIG. 5).

[0088] In particular, the first portion 81 of each airflow control wall 8 is disposed at a position corresponding to the upside flow channel 61. The smoke therefore flows dominantly through the upside flow channel 61 by the branching part 71, as described in the column of "(2.7) Flow Channel Forming Member," but part of the smoke efficiently would collide with the first portion 81. Therefore, the first portion 81 can guide to the inlet ports 40 the smoke flowing through the upside flow channel 61 to escape along the circumferential direction A3.

[0089] Thus, in consideration of the whole of the sensor 1, providing the airflow control walls 8 can reduce variation in the amount of the smoke finally flowing into the smoke detection chamber 4, even if the smoke enters the sensor 1 through the opening 510 from any direction of 360° around the sensor 1 (refer to 12 arrows Y1 shown in FIG. 5). As a result, the sensor 1 can improve the inflow property of smoke with respect to the smoke detection chamber 4. In addition, the airflow control walls 8 are formed as parts of the upper cover 52, which can contribute to stable positioning of the airflow control walls 8 with respect to the second region 412 on assembling the sensor 1.

[0090] The number of the airflow control walls 8 is not limited in particular but may be one, for example. However, the two airflow control walls 8 in the present embodiment are disposed such the second region 412 is interposed therebetween in the circumferential direction A3, which can more efficiently guide to the inlet ports 40 both of flows of the smoke, which has been divided into left and right by colliding with the second region 412. Accordingly, the two airflow control walls 8 can further reduce the chance that the flows of smoke divided into left and right hardly flows into the smoke detection chamber 4.

[0091] Note that, as described in the column of "(2.7) Flow Channel Forming Member," steam flows dominantly through the downside flow channel 62 by the branching part 71 (dividing portion Z1) of the flow channel forming member 7, but part of the steam may get over the branching part 71 to flow through the upside flow channel 61 by colliding with the airflow control wall 8. However, the groove 80 is provided in a position corresponding to the downside flow channel 62 in the present embodiment, as described above. Therefore, steam, flowing through the downside flow channel 62 along the circumferential direction A3, can easily go through the groove 80 of each airflow control wall 8. As a result, providing the groove 80 can reduce the chance that the steam gets over the branching part 71 to flow through the upside flow channel 61 by colliding with the airflow control wall 8.

[0092] The branching part 71 (dividing portion Z1) of the present embodiment has a recessed part 73 (refer to FIGS. 3 to 6), and therefore is not formed over the entire circumference of the smoke detection chamber 4. The recessed part 73 is disposed in a position of facing the second region 412. The recessed part 73 in this embodiment is formed not only in the branching part 71 (dividing portion Z1) but also in the blocking part 72. That is to say, each of the branching part 71 (dividing portion Z1) and the blocking part 72 is partially lacking in the circumferential direction A3 by providing the recessed part 73, and accordingly, has a generally C-shape when viewed along the upward/downward direction. The recessed part 73 has almost the same width as that of the second region 412 in the circumferential direction A3. In other words, almost the entire of the second region 412 is exposed through the recessed part 73, when viewed from the front of the recessed part 73.

[0093] Thus, providing the recessed part 73 allows smoke, which has entered the sensor 1 toward the second region 412, to easily flow into the space X1 between the peripheral wall 41 of the smoke detection chamber 4 and the blocking part 72 through the recessed part 73 (refer to airflow B2 shown with arrows in FIG. 5). Therefore, providing the recessed part 73 can further reduce the chance that the smoke flowing toward the second region 412 hardly flows into the smoke detection chamber 4.

[0094] In particular, while the steam is suppressed from entering the smoke detection chamber 4 by the flow channel forming member 7, the second region 412 also exists and the steam toward the second region 412 is therefore blocked by the second region 412 with high probability, even if the branching part 71 and the blocking part 72 are not provided in the place (i.e., front of the second region 412). Conversely, the inflow of the smoke may be synergistically suppressed, even if, in addition to existence of the second region 412, the branching part 71 and the blocking part 72 are provided in the place. From those points of view, providing the recessed part 73 can improve the inflow property of the smoke.

(2.9) Installation Direction

[0095] In the foregoing description, the recessed part 73 is provided in a position of facing the second region 412, of the flow channel forming member 7 of the sensor 1, in consideration of the inflow property of smoke. For example, the sensor 1 may be installed in an environment as often getting into a situation where steam flows into the smoke detection chamber 4 (place such as a dressing room adjacent to a bathroom). In this case, if the sensor 1 is installed on the installation surface 100 such that the recessed part 73 is directed to the bathroom, the steam may be allowed to enter the sensor 1 with higher probability.

[0096] In consideration of that problem, the sensor 1 further includes a mark M1, indicating an installation direction related to the circumferential direction A4 of the sensor 1, for use to install the sensor 1 onto the installation surface 100 (refer to FIGS. 2 to 6). The mark M1 is provided to the circular cylindrical body 51A of the lower cover 51, for example. The mark M1 may be implemented as a linear mark along the upward/downward direction. However, the aspect of the mark is only an example and should not be construed as limiting. For example, the mark M1 in the present embodiment is provided at a position corresponding to the recessed part 73 in the circumferential direction A4 of the sensor 1. In other words, the mark M1 is disposed such that the recessed part 73 is on a virtual line segment connecting the central point P1 of the smoke detection chamber 4 and the mark M1, when viewed from above the smoke detection chamber 4. It can be therefore said that the mark M1 indicates a direction related to the recessed part 73.

[0097] The mark M1 may be printed directly onto the lower cover 51. Alternatively, the mark M1 may be implemented as a printed sticker, stuck onto the lower cover 51. Still alternatively, the mark M1 may be implemented as a recess, or a protrusion formed on a surface of the lower cover 51.

[0098] A worker installing the sensor 1 may install the sensor 1 onto the installation surface 100 with the mark M1 being directed to the side opposite to the bathroom, which can easily avoid the recessed part 73 from being directed to the bathroom. Accordingly, the worker can install the sensor 1 such that a specific region (i.e., a region where the recessed part 73 is disposed) in the circumferential direction A4 of the sensor 1 is not directed to a specific place (e.g., a bathroom).

[0099] The mark M1 may be provided at a position corresponding to a region where no recessed part 73 is disposed. Also in this case, it can be said that the mark M1 indicates a direction related to the recessed part 73. The worker may install the sensor 1 onto the installation surface 100 with the mark M1 being directed to the bathroom, which can easily avoid the recessed part 73 from being directed to the bathroom. Accordingly, the worker can install the sensor 1 such that a specific region (i.e., a region where the recessed part 73 is not disposed) in the circumferential direction A4 of the sensor 1 is directed to a specific place (e.g., a bathroom).

(3) Variations

[0100] Note that the embodiment described above is only an exemplary one of various embodiments of the present disclosure and should not be construed as limiting. Rather, the exemplary embodiment may be readily modified in various manners depending on a design choice or any other factor without departing from the scope of the present disclosure.

[0101] Next, variations of the exemplary embodiment will be enumerated one after another. The variations to be described below may be adopted in combination as appropriate. In the following description, the exemplary embodiment described above will be hereinafter sometimes referred to as a "basic example."

[0102] In the basic example, the sensor 1 includes the airflow control walls 8. However, the airflow control walls 8 are not essential constituent elements for the sensor 1 according to the present disclosure but may be omitted as appropriate. For example, FIG. 8 shows a sensor 1A according to a first variation. Like the sensor 1 in the basic example, the sensor 1A includes a flow channel forming member 7 having a recessed part 73, and a base 2 having protruded edges 25. The sensor 1Ais however different from the sensor 1 of the basic example in that the airflow control walls 8 are not provided. The sensor 1A can also reduce the chance that erroneous detection occurs.

[0103] In the basic example, the flow channel forming member 7 of the sensor 1 has the recessed part 73. However, the recessed part 73 is not an essential constituent element for the sensor 1 according to the present disclosure. For example, FIG. 9 shows a sensor 1B according to a second variation. Like the sensor 1 in the basic example, the sensor 1B includes airflow control walls 8, and a base 2 having protruded edges 25. The sensor 1B is however different from the sensor 1 of the basic example in that the sensor 1B includes a branching part 71A provided over an entire circumference of a smoke detection chamber 4. The sensor 1B can also improve the inflow property of smoke with respect to the smoke detection chamber 4. In addition, the sensor 1B can also reduce the chance that erroneous detection occurs. Furthermore, the sensor 1B can suppress steam from flowing into the smoke detection chamber 4, even if the steam enters the sensor from any direction of 360°.

[0104] In the basic example, the recessed part 73 is formed over both of the branching part 71 and the blocking part 72. However, the recessed part 73 may be formed only in the branching part 71. In other words, the recessed part 73 may be formed only at a position corresponding to the upside flow channel 61.

[0105] In the basic example, the branching part 71 (dividing portion Z1) of the flow channel forming member 7 of the sensor 1 has a cross section bent to make a right angle as an L-shape (refer to FIG. 1). However, the shape of the branching part 71 (dividing portion Z1) is not limited in particular. For example, FIG. 10 shows a cross-sectional view of a principal part of a sensor 1C according to a third variation. The sensor 1C is different from the sensor 1 of the basic example in that the flow channel forming member 7 of the sensor 1C includes a branching part 71B (dividing portion Z1) having a sloped surface 76. The sloped surface 76 is sloped in a direction closer to the base 2, as farther away outward from an upper end of a blocking part 72. Accordingly, smoke particles more stably can get over the branching part 71B through the sloped surface 76 to flow into the smoke detection chamber 4 from the inlet port 40 on the back side of the blocking part 72, compared with the sensor 1 of the basic example.

[0106] In the basic example, the base 2 of the sensor 1 includes the protruded edges 25. However, the protruded edges 25 are not essential constituent elements for the sensor 1 according to the present disclosure. As shown in FIG. 11, the sensor 1 may not include even one protruded edge 25 and may include a base 2A including only a main body 20 and six tongue parts 26. In FIG. 11, the protruded edges 25 of the base 2 of the sensor 1 in the basic example are shown with double-dotted lines for comparison. In FIG. 11, the illustration of the heat sensitive elements 30 is omitted.

[0107] In the basic example, the number of the airflow control walls 8 is two. However, the number of the airflow control walls 8 does not have to be two but may also be one, three or more.

[0108] In the basic example, the airflow control walls 8 are disposed based on a position of the second region 412 that is the facing wall 405 facing the outer surface of the holding block 404 holding the optical element 401. However, the airflow control walls 8 do not have to be disposed based on the position of the second region 412, as long as the airflow control walls 8 controls airflow so as to make less variation in the inflow property of smoke with respect to the smoke detection chamber 4 in the circumferential direction A3.

[0109] In the basic example, the airflow control walls 8 are formed as parts of the upper cover 52. However, at least one part of each airflow control wall 8 may be provided as another member separately from the upper cover 52. For example, the first portion 81 of each airflow control wall 8 may be formed integrally with the flow channel forming member 7. Alternatively, for example, the second portion 82 of each airflow control wall 8 may be fixed to the base 2 by an adhesive or any other means.

[0110] In the basic example, the second region 412 is assumed to be the facing wall 405 facing the outer surface of the holding block 404 holding the optical element 401. However, the second region 412 may be a facing wall of the cover 4A facing an outer surface of a holding block 406 (refer to FIG. 6) holding the photosensitive element 402.

[0111] In the basic example, the smoke detection chamber 4 is mounted on the first surface 21 (upper surface) of the base 2. However, the smoke detection chamber 4 may be mounted on the second surface 22 (lower surface) of the base 2.

[0112] In the basic example, the base 2 is a circuit board on which not only the smoke detection chamber 4 but also the control unit 9 and any other circuits are mounted. However, the base 2 on which the smoke detection chamber 4 is mounted may be provided as another member separately from a circuit board on which the control unit 9 and any other circuits are mounted. Note that the base 2 in the basic example can further reduce the number of components of the sensor 1, compared with that the base 2 is provided as the other member.

[0113] In the basic example, the mark M1 indicates a direction related to the recessed part 73. However, this direction does not have to be related to the recessed part 73, as long as the mark M1 serves as a mark indicating a direction related to the specific region in the circumferential direction A4 of the sensor 1.

[0114] The mark M1 may be realized by light emitted from a light source such as an LED. In this case, light emitted from the display unit 10 as an indicating lamp may serve also as the mark M1.

(Second Embodiment)

(1) Overview

[0115] Also in the present embodiment, airflow may be gas including smoke or steam, but a sensor in the present embodiment is different from the sensor according to the first embodiment in that a slope 202 and an airflow control portion 201 are provided. Hereinafter, some features of the sensor different from those according to the first embodiment will be mainly described. In the following description, constituent elements of the sensor according to the present embodiment, which are similar to those according to the first embodiment, are assigned with the same reference signs, and explanations thereof will be omitted as appropriate. The drawings to be referred to in the following description are all schematic representations. That is to say, the ratio of the dimensions (including thicknesses) of respective constituent elements illustrated on the drawings does not always reflect their actual dimensional ratio.

[0116] As shown in FIG. 12, a sensor 1D according to the present embodiment includes a smoke detection chamber 4, an opening 510 and a dividing portion Z1. The dividing portion Z1 includes the slope 202.

[0117] The smoke detection chamber 4 has an inlet port 40 through which smoke flows into the smoke detection chamber 4. The opening 510 connects an external space SP2 and a space SP1 surrounding the smoke detection chamber 4. The slope 202 is disposed in the space SP1 surrounding the smoke detection chamber 4 and divides a gas flow channel 6 in the space SP1 surrounding the smoke detection chamber 4. The slope 202 is configured to divide the gas flow channel 6 such that a first ratio is made higher than a second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port 40 with respect to a first inflow of smoke flowing into the gas flow channel 6 through the opening 510. The second ratio is a ratio of an amount of steam reaching the inlet port 40 with respect to a second inflow of steam flowing into the gas flow channel 6 through the opening 510.

[0118] As shown in FIG. 13, the slope 202 (dividing portion Z1) is provided around an entire circumference of the smoke detection chamber 4. As shown in FIGS. 13 and 14, the base 2 has a generally disk shape as a whole. In the present embodiment, one or more heat sensitive elements 30 (six in the example of FIG. 13) of a heat detection unit 3 are disposed on an outer peripheral part 23 of the base 2. The base 2 includes six tongue parts 26 on which the heat sensitive elements 30 are provided, respectively. Each tongue part 26 is a part on which a corresponding one of the six heat sensitive elements 30 is mounted. The six tongue parts 26 are arranged at nearly regular intervals along the circumferential direction so as to divide the outer peripheral part 23 of the base 2 into nearly six equal parts. Each heat sensitive element 30 is mounted on the upper surface near the tip of a corresponding tongue part 26. Each of the six tongue parts 26 has a through hole 260 that is disposed in a region inside a corresponding heat sensitive element 30 and opened in a rectangular shape. The respective through holes 260 are provided adjacent to the heat sensitive elements 30. Providing the through hole 260 adjacent to each heat sensitive element 30 allows the area of the base 2 to be reduced around the heat sensitive element 30, thus reducing the chance of the temperature of the heat of the heat sensitive element 30 being lowered by being transferred through the base 2, or the chance of heat generated by the other circuit components mounted on the main body 20 affecting the heat sensitive element 30. That is to say, the through hole 260 improves the thermal insulation properties.

[0119] The sensor 1D includes the airflow control portion 201 disposed over an outer periphery of the opening 510 in a vertical direction. A circular cylindrical body 51Ahas an outer peripheral surface 54 including a first peripheral surface 208 disposed on the upside and a second peripheral surface 204 disposed on the downside. The first peripheral surface 208 is along a vertical direction A2. The second peripheral surface 204 is sloped inward so as to make a taper angle θv with respect to the first peripheral surface 208. The second peripheral surface 204 of the circular cylindrical body 51A corresponds to the airflow control portion 201. The airflow control portion 201 provides, as the taper angle θv of the airflow control portion 201, an angle made by the first peripheral surface 208 and the second peripheral surface 204, of the circular cylindrical body 51A of the upper cover 53 of the sensor 1D, and controls the airflow to flow into the opening 510 from the external space SP2 by the taper angle θv. "Controlling the airflow" mentioned herein corresponds to controlling the airflow such that smoke is caused to more stably enter the sensor, but steam is suppressed from entering the sensor, and more specifically, corresponds to controlling the airflow such that, while the smoke is caused to more stably flow into the opening 510 by using the diffusion force of the smoke, the steam is suppressed from flowing into the opening 510 by using the inertial force of the steam. The airflow control portion 201 further controls a total amount of the airflow flowing into the opening 510. Regarding the airflow flowing into the opening 510, the airflow control portion 201 controls such that the smoke is caused to more stably flow into the opening 510 depending on the smoke having greater diffusion force and smaller inertial force, the steam is suppressed from flowing into the opening 510 depending on the steam having smaller diffusion force and greater inertial force. As a result, the airflow control portion 201 controls the smoke to more easily flow into the opening 510, compared with the steam.

[0120] Thus, the sensor 1D in the present embodiment includes the airflow control portion 201, which can cause the airflow to flow into the opening 510 such that the smoke more easily flows thereinto. Therefore, the sensor 1D can improve the inflow property of smoke with respect to the smoke detection chamber 4.

(2) Detail

(2.1) Overall Configuration

[0121] Next, an overall configuration of the sensor 1D according to the present embodiment will be described in detail. The sensor 1D is implemented as a combination fire sensor for detecting both heat and smoke, like the first embodiment.

[0122] The sensor 1D includes a smoke detection chamber 4 (smoke detection unit) and a slope 202 of a dividing portion Z1. The sensor 1D further includes a base 2 and a housing 5. The sensor 1D further includes a heat detection unit 3, a control unit 9 and a display unit 10. The sensor 1D further includes a disklike attachment base to be fixed to an installation surface 100 by screws or any other means. The sensor 1D may be installed on the installation surface 100 by an attachment part provided on an upper surface of the housing 5 being attached removably to the attachment base.

[0123] The sensor 1D further includes a communications unit 11 for transmitting, on detecting a fire, a signal serving as an alert to the presence of the fire to an external alarm device or any other device, and receiving a signal from the alarm device, for example.

[0124] The sensor 1D may be supplied with power from either a commercial power supply or a battery provided inside the housing 5, whichever is appropriate.

[0125] Configurations of the components described above are generally common with those described from "(2.2) Housing" to "(2.6) Control Unit," of the first embodiment, and detailed explanations thereof will be omitted as appropriate in the present embodiment.

(2.2) Slope

[0126] The slope 202 (dividing portion Z1) in the present embodiment is provided to form a flow channel extending from the opening 510 to the inlet port 40 of the smoke detection chamber 4. The sensor 1D includes the slope 202 (dividing portion Z1) that has a sloped surface 203, which is disposed between the second space SP4 and the third space SP5 and sloped to extend vertically upward, as closer to the smoke detection chamber 4. The slope 202 (dividing portion Z1) is made of a synthetic resin and may be made of flame-retardant ABS resin, for example. As shown in FIG. 14, the slope 202 (dividing portion Z1) has a generally ring shape as a whole and has an inner peripheral surface 75A formed into a cylindrical shape. The slope 202 (dividing portion Z1) extends upward in the vertical direction A2 and toward the inner peripheral surface 75A in a radial direction of the sensor 1D, and has, as a concave, the sloped surface 203. The slope 202 (dividing portion Z1) is formed into an annular shape. The slope 202 (dividing portion Z1) further has an upper surface 207 of which height is constant in the horizontal direction. The upper surface 207 is formed into an annular shape with a hole in a center thereof to match with the inner peripheral surface 75A. That is to say, the slope 202 (dividing portion Z1) is provided around an entire circumference of the smoke detection chamber 4. Alternatively, the slope 202 may be formed into a generally C-shape to being partially lacking in the circumferential direction.

[0127] As shown in FIG. 12, when the cross-section of the slope 202 (dividing portion Z1) is viewed, a horizontal plane (perpendicular to the vertical direction A2 of the sensor 1D) and the sloped surface 203 generally make a taper angle θr. In FIG. 12, "b2" denotes a length of the sloped surface 203 in the horizontal direction, and "b3" denotes a length of the upper surface 207 of which height is constant. That is to say, a length of the slope 202 in the horizontal direction corresponds to a sum of the lengths "b2" and "b3."

[0128] Specifically, the slope 202 (dividing portion Z1) divides the space SP1 surrounding the smoke detection chamber 4 into: a space through which smoke flows dominantly to enter the smoke detection chamber 4; and a space through which steam flows dominantly not to enter the smoke detection chamber 4.

[0129] The slope 202 (dividing portion Z1) is disposed between the second space SP4 and the third space SP5 and sloped to extend vertically upward, as closer to the smoke detection chamber 4. The slope 202 (dividing portion Z1) divides a gas flow channel 6 to the first space SP3, the second space SP4 and the third space SP5, together with the upper cover 53 obtained by partially modifying the upper cover 52 in the first embodiment. That is to say, the slope 202 (dividing portion Z1) is configured to divide the space SP1 surrounding the smoke detection chamber 4 to the first space SP3, the second space SP4 and the third space SP5 to cause smoke, which has flowed through the third space SP5, to more stably flow into the smoke detection chamber 4 from the inlet port 40. Specifically, the slope 202 (dividing portion Z1), the first space SP3, the second space SP4 and the third space SP5 are surrounded by the upper cover 53, the base 2 and the smoke detection chamber 4. In the cross sectional view of FIG. 12, the first space SP3 is a space around the opening 510 and outside an inner surface 209 of the circular cylindrical body 51A (refer to FIG. 12). The second space SP4 is a space in a range from the inner surface 209 to an upper corner P0 of the slope 202 (refer to an enlarged view in FIG. 12). The third space SP5 is a space in a range from the upper corner P0 of the slope 202 to the inlet port 40 of the smoke detection chamber 4. The above definitions relating to the ranges of the first space SP3, the second space SP4 and the third space SP5 are only examples and there is no intention to strictly define the ranges of these spaces. The first space SP3, the second space SP4 and the third space SP5 are formed as ring-shaped spaces around the smoke detection chamber 4.

[0130] As shown in FIG. 12, the opening 510 and the first space SP3 are adjacent to each other in one direction directed from the opening 510 to the smoke detection chamber 4, the first space SP3 and the second space SP4 are adjacent to each other in the one direction, and the second space SP4 and the third space SP5 are adjacent to each other in the one direction. In this embodiment, regarding the first inflow of smoke and the second inflow of steam, the first ratio of smoke is made higher than the second ratio of steam in the third space SP5. Note that, in the first space SP3 and the second space SP4, this condition may or may not be satisfied.

[0131] Regarding volumes of the first, second and third spaces SP3 to SP5, the second space SP4 has a larger volume than that of each of the first space SP3 and the third space SP5. The "volume" of each of the first, second and third spaces SP3 to SP5 mentioned herein corresponds to a volume of a corresponding whole space formed into a ring-shape.

[0132] As shown in FIG. 12, the second space SP4 has a larger cross-sectional area than that of each of the first space SP3 and the third space SP5, in cross sections of the first, second and third spaces SP3 to SP5, taken along a plane including one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) and the vertical direction A2. The one direction (directed from the opening 510 to the smoke detection chamber 4) mentioned herein corresponds to a direction along a radial direction of the sensor 1D, when viewed from the opening 510 toward the smoke detection chamber 4, of the sensor 1D.

[0133] In addition, as shown in FIG. 12, the second space SP4 is longer than each of the first space SP3 and the third space SP5 in the vertical direction A2 of the sensor 1D, in the cross sections of the first, second and third spaces SP3 to SP5, taken along the plane including the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) and the vertical direction A2. The "length of each space in the vertical direction A2" mentioned herein corresponds to the maximum length of each space in the vertical direction A2 with respect to the horizontal direction in the cross sections, taken along the plane including the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) and the vertical direction A2, as shown in FIG. 12. In FIG. 12, the lengths of the first, second and third spaces SP3 to SP5 in the vertical direction A2 are denoted by SM1, SM2 and SM3, respectively.

[0134] Similarly, as shown in FIG. 12, the second space SP4 is longer than each of the first space SP3 and the third space SP5 in the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D), in the cross sections of the first, second and third spaces SP3 to SP5, taken along the plane including the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) and the vertical direction A2. The "length of each space in the horizontal direction" mentioned herein corresponds to a length between a start point and an end point of each space, along the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) in the cross sections taken along the plane including the one direction (directed from the opening 510 to the smoke detection chamber 4, of the sensor 1D) and the vertical direction A2, as shown in FIG. 12. In FIG. 12, the lengths of the first, second and third spaces SP3 to SP5 in the horizontal direction are denoted by SL1, SL2 and SL3, respectively. As shown in FIG. 12, the length of each space in the horizontal direction corresponds to the maximum length of each space in the horizontal direction.

[0135] That is to say, the second space SP4 has: a larger volume; a larger cross-sectional area in the radial direction;

a longer length in the vertical direction A2, of the cross section in the radial direction; and a longer length in the radial direction, of the cross section in the radial direction, than those of each of the first space SP3 and the third space SP5.

[0136] The sensor 1D includes the slope 202 (dividing portion Z1) having the sloped surface 203, which is disposed between the second space SP4 and the third space SP5 and sloped to extend vertically upward, as closer to the smoke detection chamber 4. The horizontal plane (perpendicular to the vertical direction of the sensor 1D) and the sloped surface 203 of the slope 202 (dividing portion Z1) generally make the taper angle θr. As shown in FIG. 12, in the cross section, the sloped surface 203 is sloped to extend vertically upward, as going toward the inside in one direction (directed from the opening 510 to the smoke detection chamber 4), and has a curved shape, recessed downward in the vertical direction A2. As shown in the enlarged view of FIG. 12, the taper angle θr is assumed to be an angle made by a virtual line b4, connecting an upper corner P0 and a lower corner Q0 of the sloped surface 203, and the first surface 21 (upper surface) of the base 2.

[0137] Next, the effect of the taper angle θr of the slope 202 (dividing portion Z1) on an inflow time of smoke (related to a response of the sensor 1D with respect to smoke) and a reduction rate of steam will be described. The "inflow time of smoke related to the response of the sensor 1D with respect to smoke" mentioned herein means a time until smoke, which has entered the sensor 1D from the opening 510, reaches the smoke detection chamber 4 via the space SP1 surrounding the smoke detection chamber 4. The inflow time of smoke is an index indicating the response of the sensor 1D with respect to smoke. On the other hand, the "reduction rate of steam" represents that, when the taper angle θr is modified based on a certain taper angle (reference angle), how much the amount of steam in the taper angle θr thus modified can be reduced with respect to that in the reference angle. The graph related to the reduction rate of steam shows that the amount of steam can be reduced in response to a reduction in the value of the reduction rate with respect to the amount of steam entering the smoke detection chamber 4 in case of the certain taper angle (reference angle). The graphs of FIG. 15A show ratios when the certain taper angle θr (reference angle) is set to 60 degrees, for example. That is to say, the graphs of FIG. 15A show the ratios defined as "1," when the taper angle is 60 degrees. As shown in FIG. 15A, when the taper angle θr falls within a range of 35 degrees to 90 degrees, a graph X50 representing the inflow time of smoke is not changed significantly. Therefore, even if the taper angle θr of the slope 202 (dividing portion Z1) is modified within the range of 35 degrees to 90 degrees, it can be understood that the response of the sensor 1D to a fire is hardly changed. On the other hand, a graph X60 representing the reduction rate of steam is reduced significantly in response to an increase in the taper angle θr. In particular, the steam can be reduced more significantly, as the taper angle θr is modified closer to 90 degrees from 60 degrees. Accordingly, setting the taper angle θr to an appropriate value can reduce the amount of steam entering the smoke detection chamber 4, even when the steam has entered the sensor 1D, and further can maintain the inflow time of smoke without impairing the response with respect to smoke, when the smoke has entered the sensor 1D. For example, the taper angle θr is preferably set to fall within a range of 60 degrees to 90 degrees, and more preferably a range of 70 degrees to 80 degrees. The taper angle θr in FIG. 12 is 70 degrees, as one example. That is to say, increasing the taper angle θr hardly impairs the response of the sensor 1D with respect to smoke, when the smoke has entered the sensor 1D, but can reduce the ratio of the steam entering the smoke detection chamber 4, even when the steam has entered the sensor 1D. Therefore, it can be said that the slope 202 (dividing portion Z1) can suppress the erroneous alarm by steam entering the sensor 1D, while substantially maintaining the response with respect to smoke by a fire.

(2.3) Airflow Control Portion

[0138] The sensor 1D includes the airflow control portion 201 configured to control the amount of airflow that flows in the opening 510 of the sensor 1D from the external space SP2. The airflow control portion 201 is disposed over an outer periphery of the opening 510 in the vertical direction and configured to control gas so as to flow in the opening 510. The airflow control portion 201 is configured to separate a main airflow including smoke or steam in the external space SP2 to: a first airflow not flowing into the gas flow channel 6 from the opening 510; and a second airflow flowing into the gas flow channel 6 from the opening 510. The airflow control portion 201 is configured to control the main airflow such that a ratio of an amount of the smoke in the second airflow with respect to an amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than a ratio of an amount of the steam in the second airflow with respect to an amount of the steam in the first airflow when the main airflow includes the steam. Specifically, as shown in FIG. 12, the airflow control portion 201 includes the second peripheral surface 204 derived from the first peripheral surface 208, of the outer peripheral surface 54 of the circular cylindrical body 51A generally compressed, of which both ends in the upward/downward direction are opened, in the upper cover 53 of the sensor 1D. The taper angle θv is made by the first peripheral surface 208 and the second peripheral surface 204 of the outer peripheral surface 54 of the circular cylindrical body 51A. When the taper angle θv is increased, the airflow including smoke or steam is caused to more stably flow into the opening 510 of the sensor 1D and the amount of the airflow flowing into the opening 510 is therefore increased. On the other hand, when the taper angle θv is reduced, the airflow including smoke or steam is suppressed from flowing into the opening 510 of the sensor 1D and the amount of the airflow flowing into the opening 510 is therefore reduced. That is to say, adjusting the taper angle θv can control the airflow including smoke or steam entering the sensor 1D.

[0139] FIG. 15B shows a relationship between the taper angle θv and each of the inflow time of smoke and the reduction rate of steam. FIG. 15B shows a graph X10 representing the inflow time of smoke and a graph X20 representing the reduction rate of steam, as ratios when 30 degrees of the taper angle θv is set as a reference angle. The graph related to the reduction rate of steam shows that the amount of steam can be reduced in response to a reduction in the value of the reduction rate with respect to the 30 degrees of the taper angle (reference angle). Even when the taper angle θv is modified in a range of 0 degrees to 30 degrees, the graph X10 representing a change rate in the inflow time of smoke is not changed significantly. On the other hand, in the graph X20 representing the reduction rate of steam, the change ratio is greater, as the taper angle θv is closer to 0 degrees. That is to say, increasing the taper angle θv hardly impairs the response of the sensor 1D with respect to smoke, but can reduce the amount of steam with respect to the taper angle as the reference angle (30 degrees in FIG. 15B) when the airflow includes the steam. Therefore, it can be said that the taper angle θv of the airflow control portion 201 can increase a ratio of smoke by a fire, entering the sensor 1D from the opening 510, but reduce a ratio of steam entering the sensor 1D from the opening 510. Note that, for example, the taper angle θv is preferably set to fall within a range of 0 degrees to 30 degrees, and more preferably a range of 0 degrees to 15 degrees. The taper angle θv in FIG. 12 is 11 degrees, as one example.

[0140] As shown in FIG. 12, "a1" denotes a thickness of a part (i.e., a size in the radial direction), of the circular cylindrical body 51A of the lower cover 51, corresponding to the lower end of the surface inclined at the taper angle θv of the airflow control portion 201. The thickness a1 relates to an effect of suppressing steam from entering the sensor 1D, while maintaining the response (smoke response) of the sensor 1D with respect to smoke. FIG. 15C shows a relationship between the thickness a1 and each of the inflow time of smoke and the reduction rate of steam. FIG. 15C shows a graph X30 representing the inflow time of smoke and a graph X40 representing the reduction rate of steam, as ratios with respect to when the thickness a1 is set to 9 mm as a reference. When the thickness a1 is modified from 9 mm to 1 mm, the graph X30 representing the inflow time of smoke is not changed significantly with respect to the reference (the thickness: 9 mm), but in the graph X40 representing the reduction rate of steam, the amount of steam is reduced, as the thickness a1 is reduced from the reference (the thickness: 9 mm). That is to say, reducing the thickness a1 hardly impairs the response of the sensor 1D with respect to smoke, but can reduce the amount of steam entering the sensor 1D. Therefore, it can be said that adjusting the thickness a1 of the airflow control portion 201 can increase a ratio of smoke by a fire, entering the sensor 1D from the opening 510, but reduce a ratio of steam entering the sensor 1D from the opening 510. The particle size of steam is, for example, about 10 μm, but the particle size of smoke is, for example, about 0.1 μm. Furthermore, the mass of the smoke particle is less than that of the steam particle. Thus, the inertial force of the smoke particles is smaller than that of the steam particles. Since the smoke has higher diffusion, the smoke is hardly affected by the thickness a1, even when the thickness a1 is small. On the other hand, when the thickness a1 is reduced such that the inner surface 209 of the circular cylindrical body 51A is made closer to the external space SP2, the second space SP4 is made wider, and therefore, even the steam with the greater inertial force is caused to more stably swirl in the second space SP4. Conversely, when the thickness a1 is increased such that the inner surface 209 of the circular cylindrical body 51A is made closer to the smoke detection chamber 4, the second space SP4 changing the gas flow channel 6 is made narrower, and therefore, the steam is suppressed from swirling in the second space SP4, and the amount of steam reaching the smoke detection chamber 4 is increased.

(2.4) Slope (Dividing portion Z1) and Airflow Control Portion

[0141] As described above, the sensor 1D includes the slope 202 (dividing portion Z1) and the airflow control portion 201. As shown in FIG. 12, "a1" denotes a thickness of the airflow control portion 201 in one direction directed to the smoke detection chamber from the opening 510, "a2" denotes a length of the airflow control portion 201 in the vertical direction, and "θv" denotes a taper angle made by the first peripheral surface 208 and the second peripheral surface 204 of the outer peripheral surface 54 of the circular cylindrical body 51A. In the sensor 1D of the present embodiment, for example, the thickness a1 is 5 mm, the length a2 is 10.64 mm, the taper angle θv is 11 degrees. Furthermore, as shown in FIG. 12, regarding the sloped surface 203 of the slope 202 (dividing portion Z1), "b1" denotes a distance between the airflow control portion 201 and the slope 202 (dividing portion Z1), "b2" denotes a length of the sloped surface 203 in the radial direction, and "b3" denotes a length of a part of the slope 202 (dividing portion Z1), of which height is constant. In the sensor 1D of the present embodiment, for example, the distance b1 is 13.65 mm, the length b2 is 4.29 mm, and the length b3 is 6.11 mm. Note that, those numerical values are only one examples and should not be construed as limiting.

(3) Operation

<Operation example 1> Case that Smoke enters Sensor

[0142] Next, the case that smoke enters the sensor will be described. As described above, the airflow control portion 201, which is provided over the outer periphery of the opening 510 in the vertical direction, separates part of the smoke form the airflow including the smoke. The smoke is caused to more stably enter the space SP1 including the slope 202 (dividing portion Z1) from the opening 510 by the airflow control portion 201 with the taper angle θv and the thickness a1. In other words, the smoke more easily enters the sensor 1D from the opening 510, rather than be badly affected by the airflow control portion 201. Accordingly, a ratio of smoke included in the airflow, which enters the sensor from the opening 510 by the airflow control portion 201, is further increased, compared with that of smoke included in the airflow in the external space SP2.

[0143] Specifically, as shown in FIG. 12, the airflow control portion 201 forms a branched smoke flow 65, which enters into the opening 510, from a smoke flow 63 in the external space SP2. A ratio of the smoke flow 63 and the branched smoke flow 65 is, for example, a ratio of 75% to 25%. That is to say, it means that most of gas including the smoke does not flow into the opening 510 by the airflow control portion 201. Note that, those numerical values are only one examples and should not be construed as limiting.

[0144] Next, the airflow including the smoke, which has flowed into the opening 510 of the sensor 1D, reaches the first space SP3 of the space SP1. The airflow further moves to the inside of the sensor 1D and reaches the second space SP4 from the first space SP3. As described above, the second space SP4 has a larger volume and a larger cross-section area taken along a plane including one direction (directed to the smoke detection chamber 4 from the opening 510) and the vertical direction (perpendicular to the one direction) than those of each of the first space SP3 and the third space SP5. In addition, lengths in the vertical direction and in one direction (directed to the smoke detection chamber 4 from the opening 510), of the cross section of the second space SP4, taken along a plane including the one direction and the vertical direction (perpendicular to the one direction) are longer than those of each of the first space SP3 and the third space SP5. Note that, all of those conditions are preferably satisfied, but this is not essential.

[0145] Furthermore, the slope 202 (dividing portion Z1) having the sloped surface 203 inclined at the taper angle θr is provided between the second space SP4 and the third space SP5.

[0146] Thus, as shown in FIG. 12, the airflow, which has flowed into the second space SP4, flows through the second space SP4 to be swirled upward from below in the vertical direction, then outward from the inside in one direction (directed to the smoke detection chamber 4 from the opening 510 of the sensor 1D), and then downward from above in the vertical direction. The particle size of smoke is small, and accordingly, the diffusion force of smoke is great, but the inertial force of smoke is small. Therefore, the smoke can partially flow into the third space SP5 from the second space SP4.

[0147] Specifically, as shown in FIG. 12, the sensor 1D includes the slope 202, and furthermore, the cross section area in the cross section of the second space SP4, taken along a plane including one direction (directed to the smoke detection chamber 4 from the opening 510) and the vertical direction A2 is made larger than that of each of the first space SP3 and the third space SP5, taken along the plane, thereby a smoke vortex flow 67B being formed in the second space SP4. A smoke separation flow 67A is also formed so as to be separated from the smoke vortex flow 67B. The smoke separation flow 67A flows into the third space SP5 from the second space SP4 and then enters the smoke detection chamber 4 from the inlet port 40.

[0148] As described above, the diffusion force of the smoke particles is great, but the inertial force of the smoke particles is small. Thus, the smoke, which has flowed into the second space SP4, forms the smoke vortex flow 67B by the slope 202, while forming the smoke separation flow 67A moving toward the third space SP5 from the second space SP4. In other words, a space, which is disposed around the smoke detection chamber 4 and through which the smoke flows dominantly to enter the smoke detection chamber, is provided as a part of the gas flow channel 6. A ratio of smoke in the smoke separation flow 67A moving toward the third space SP5 from the second space SP4 is larger than a ratio of smoke in the branched smoke flow 65, which has entered the sensor from the opening 510. That is to say, the slope 202 (dividing portion Z1) forms the space through which the smoke flows dominantly to enter the smoke detection chamber 4 (i.e., the third space SP5 in the present embodiment).

[0149] Therefore, the slope 202 (dividing portion Z1) has the taper angle θr, and furthermore, can form the smoke vortex flow 67B and the smoke separation flow 67A, using a difference between the sizes of the first space SP3, the second space SP4 and the third space SP5. A ratio of smoke in the airflow, which has flowed into the third space SP5, is larger than that of the airflow in the second space SP4. The sensor 1D therefore can detect a fire to give a fire alarm, by the airflow, which has reached the smoke detection chamber 4 from the third space SP5 via the inlet port 40.

<Operation example 2> Case that Steam enters Sensor

[0150] Next, the case that steam enters the sensor will be described. As described above, the airflow control portion

201, which is provided over the outer periphery of the opening 510 in the vertical direction, separates part of the steam form the airflow including the steam. The steam is suppressed from entering the space SP1 from the opening 510 by the airflow control portion 201 with the taper angle θv and the thickness a1. In other words, the steam is affected by the airflow control portion 201, and therefore does not sufficiently enter the sensor 1D from the opening 510. Accordingly, a ratio of steam included in the airflow, which enters the sensor from the opening 510 by the airflow control portion 201, is further reduced, compared with that of steam included in the airflow in the external space SP2. The particle size of steam is large, and accordingly, the inertial force of steam is great, but the diffusion force of steam is small. Therefore, most of the steam is suppressed from entering the sensor 1D from the opening 510 by the effect of the airflow control portion 201 and the properties of the steam itself mentioned above.

[0151] Specifically, as shown in FIG. 12, the airflow control portion 201 forms a branched steam flow 66, which enters into the opening 510, from a steam flow 64 in the external space SP2. A ratio of the steam flow 64 and the branched steam flow 66 is, for example, a ratio of 75% to 25%. That is to say, it means that most of gas including the steam does not flow into the opening 510 by the airflow control portion 201. Note that, those numerical values are only one examples and should not be construed as limiting.

[0152] Next, the airflow including the steam, which has flowed into the opening 510 of the sensor 1D, reaches the first space SP3 of the space SP1. The airflow further moves to the inside of the sensor 1D and reaches the second space SP4 from the first space SP3. As described above, the second space SP4 has a larger volume and a larger cross-section area taken along a plane including one direction (directed to the smoke detection chamber 4 from the opening 510) and the vertical direction (perpendicular to the one direction) than those of each of the first space SP3 and the third space SP5. In addition, lengths in the vertical direction and in one direction (directed to the smoke detection chamber 4 from the opening 510), of the cross section of the second space SP4, taken along a plane including the one direction and the vertical direction (perpendicular to the one direction) are longer than those of each of the first space SP3 and the third space SP5. Furthermore, the slope 202 (dividing portion Z1) having the sloped surface 203 inclined at the taper angle θr is provided between the second space SP4 and the third space SP5. Thus, as shown in FIG. 12, the airflow, which has flowed into the second space SP4 (where the slope 202 (dividing portion Z1) is provided), flows through the second space SP4 to be swirled upward from below in the vertical direction, then outward from the inside in one direction (directed to the smoke detection chamber 4 from the opening 510 of the sensor 1D), and then downward from above in the vertical direction. In this case, the particle size of the steam is larger than that of the smoke, and also the mass of the steam particle is larger than that of the smoke, and accordingly, the inertial force of the steam is greater than that of the smoke, but the diffusion force of the steam is smaller than that of the smoke. Therefore, the steam would flow to swirl in the second space SP4.

[0153] Specifically, as shown in FIG. 12, the sensor 1D includes the slope 202, and furthermore, the cross section area in the cross section of the second space SP4, taken along a plane including one direction (toward the smoke detection chamber 4 from the opening 510) and the vertical direction A2 is made larger than that of each of the first space SP3 and the third space SP5, taken along the plane, thereby a steam vortex flow 68B being formed in the second space SP4. A steam separation flow 68A is also formed so as to be separated from the steam vortex flow 68B. The steam separation flow 68A flows into the third space SP5 from the second space SP4 and then enters the smoke detection chamber 4 from the inlet port 40.

[0154] However, as described above, the diffusion force of the steam particles is smaller than that of the smoke particles, but the inertial force of the steam particles is greater than that of the smoke particles, and therefore, the steam vortex flow 68B becomes a main airflow, and the steam separation flow 68A moving toward the third space SP5 from the second space SP4 is sufficiently smaller than the steam vortex flow 68B. A ratio of steam in the branched steam flow 66, which has entered the sensor from the opening 510, is larger than a ratio of steam in the steam separation flow 68A moving toward the third space SP5 from the second space SP4. That is to say, the slope 202 (dividing portion Z1) forms a space through which the steam flows dominantly not to enter the smoke detection chamber 4 (i.e., the second space SP4 in the present embodiment).

[0155] Therefore, the slope 202 (dividing portion Z1) has the taper angle θr, and furthermore, can form the space through which the steam flows dominantly not to enter the smoke detection chamber 4, using a difference between the sizes of the first space SP3, the second space SP4 and the third space SP5. A ratio of steam in the airflow, which has flowed into the third space SP5, is smaller than that of the airflow in the second space SP4. The sensor 1D therefore can suppress the chance that a fire is erroneously detected and an erroneous alarm is given by the airflow including the steam, which has reached the smoke detection chamber 4 from the third space SP5 via the inlet port 40.

(4) Advantages

[0156] The sensor 1D includes the smoke detection chamber 4, the opening 510 and the slope 202 (dividing portion Z1). The smoke detection chamber 4 has the inlet port 40 through which smoke flows into the smoke detection chamber 4. The opening 510 connects the external space SP2 and the space SP1 surrounding the smoke detection chamber 4.

The slope 202 (dividing portion Z1) is disposed in the space SP1 surrounding the smoke detection chamber 4 to divide the gas flow channel 6. The dividing portion Z1 is configured to divide the gas flow channel 6 such that the first ratio is made higher than the second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port 40 with respect to the first inflow of smoke flowing into the gas flow channel 6 through the opening 510. The second ratio is a ratio of an amount of steam reaching the inlet port 40 with respect to the second inflow of steam flowing into the gas flow channel 6 through the opening 510.

[0157] According to this configuration, dividing the gas flow channel 6 can suppress the erroneous alarm of the sensor 1D.

[0158] The slope 202 (dividing portion Z1) is provided to form, as the gas flow channel 6, the first space SP3, the second space SP4 and the third space SP5. The external space SP2 and the first space SP3 are adjacent to each other in one direction directed from the opening 510 to the smoke detection chamber 4, of the slope 202 (dividing portion Z1), the first space SP3 and the second space SP4 are adjacent to each other in the one direction, and the second space SP4 and the third space SP5 are adjacent to each other in the one direction. The second space SP4 has a larger cross-sectional area than that of each of the first space SP3 and the third space SP5, in cross section taken along a plane including the one direction (directed from the opening 510 to the smoke detection chamber 4) and the vertical direction, of the sensor 1D.

[0159] According to this configuration, the slope 202 (dividing portion Z1) is provided, and the cross-sectional area of the second space SP4 is larger than that of each of the first space SP3 and the third space SP5. Therefore, gas, which has flowed into the second space SP4, flows to be swirled upward from below in the vertical direction in the second space SP4, then outward from the inside in the second space SP4, and then downward from above in the vertical direction in the second space SP4. When the gas includes steam, the steam flows to be swirled according to the inertial force. On the other hand, when the gas includes smoke, the smoke can flow into the third space SP5 from the second space SP4 according to the diffusion force. Also, the smoke can be separated from the steam by the slope 202 (dividing portion Z1) and the relative size of the second space SP4. Therefore, the erroneous alarm of the sensor 1D by the steam can be suppressed.

[0160] The slope 202 (dividing portion Z1) has the sloped surface 203, which is disposed between the second space SP4 and the third space SP5 and sloped to extend vertically upward, as closer to the smoke detection chamber 4 in one direction directed to the smoke detection chamber 4 from the opening 510.

[0161] According to this configuration, the slope 202 (dividing portion Z1) cause gas including smoke or steam to flow to be swirled in the second space SP4. When the gas including smoke or steam flows to be swirled, the slope 202 divides, by using the diffusion force of the smoke and the inertial force of the steam, the gas flow channel 6 such that the first ratio is made higher than the second ratio, the first ratio being a ratio of an amount of the smoke reaching the inlet port 40 with respect to the first inflow of the smoke flowing into the gas flow channel 6 through the opening 510, and the second ratio being a ratio of an amount of the steam reaching the inlet port 40 with respect to the second inflow of the steam flowing into the gas flow channel 6 through the opening 510. Therefore, the erroneous alarm of the sensor 1D by the steam can be suppressed.

[0162] The sensor 1D includes the airflow control portion 201 disposed over the outer periphery of the opening 510 in the vertical direction and configured to control gas so as to flow in the opening 510. The airflow control portion 201 is configured to separate the main airflow including smoke or steam in the external space SP2 to: the first airflow not flowing into the gas flow channel 6 from the opening 510; and the second airflow flowing into the gas flow channel 6 from the opening 510. The airflow control portion 201 is configured to control the airflow such that a ratio of an amount of the smoke in the second airflow with respect to an amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than a ratio of an amount of the steam in the second airflow with respect to an amount of the steam in the first airflow when the main airflow includes the steam.

[0163] According to this configuration, while controlling the total amount of gas, the airflow control portion 201 separates, by using the great diffusion force and the small inertial force of the smoke, the main airflow including smoke or steam in the external space SP2 to: the first airflow not flowing into the gas flow channel 6 from the opening 510; and the second airflow flowing into the gas flow channel from the opening 510. The airflow control portion 201 controls the airflow such that the ratio of the amount of the smoke in the second airflow with respect to the amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than the ratio of the amount of the steam in the second airflow with respect to the amount of the steam in the first airflow when the main airflow includes the steam. In particular, when the main airflow includes the steam, the airflow control portion 201 can reduce the amount of the steam in the second airflow by using that the diffusion force of the steam is smaller than that of the smoke, but the inertial force of the steam is greater than that of the smoke.

(5) Variations

[0164] The foregoing embodiments are mere ones of various embodiments of the present disclosure. Various modifications may be made to the foregoing embodiments depending on design and the like as long as the object of the present disclosure is achieved. Hereinafter, variations of the foregoing embodiments will be listed. The following variations may be adopted in combination as appropriate.

[0165] In the second embodiment, both of the airflow control portion 201 and the slope 202 (dividing portion Z1) are provided. However, this is only an example and should not be construed as limiting. The combination of the airflow control portion 201 and the airflow control wall(s) 8 in the first embodiment may be adopted. Alternatively, only the slope 202 (dividing portion Z 1) may be provided without the airflow control portion 201 being provided. Still alternatively, the combination of the airflow control portion 201 and the branching part 71 in the first embodiment may be adopted.

[0166] In the second embodiment, as shown in FIG. 19, the slope 202 (dividing portion Z1) has the concave with a curved shape, as a cross-sectional shape in the vertical direction. However, this is only an example and should not be construed as limiting. As shown in FIG. 19, the cross-sectional shape in the vertical direction may be a linear shape, for example. In case of the linear shape, a sensor 1H may include a slope 202A having a sloped surface 203A sloped at a taper angle θr with respect to the horizontal plane of the sensor 1H.

[0167] In the second embodiment, the airflow control portion 201 and the slope 202 (dividing portion Z1) are provided. However, this is only an example and should not be construed as limiting. As shown in FIG. 16, the airflow control portion 201 may further include a protrusion 205 for restricting airflow. A sensor 1E shown in FIG. 16 includes the protrusion 205, which can restrict the airflow entering the sensor from the opening 510. Accordingly, steam (having a greater inertial force, but a smaller diffusion force than those of smoke) is further suppressed from entering the sensor from the opening 510, compared with the second embodiment. Specifically, as shown in FIG. 16, the gas flow channel 6 is divided to: a flow channel 69A through which gas including smoke or steam mainly flows; and a flow channel 69B through which part of the gas enters the sensor 1D from the opening 510. Thus, a ratio of smoke in the gas flowing into the opening 510 is increased, compared with the gas in the external space SP2, by the combination of the airflow control portion 201 and the protrusion 205. On the other hand, when the gas includes steam, a ratio of the steam flowing through the flow channel 69B can be lower than that of the steam flowing through the flow channel 69A. In the sensor 1E shown in FIG. 16, the protrusion 205 has a triangle, as a cross-sectional shape in the vertical direction. However, this is only an example and should not be construed as limiting. The cross-sectional shape of the protrusion 205 in the vertical direction may be a square, a rectangle, a trapezoid, or a semicircle, for example.

[0168] In the second embodiment, the second peripheral surface 204 is linear, when viewed in the cross section of the airflow control portion 201, in the vertical direction perpendicular to the radial direction, which has the taper angle θv made by the first peripheral surface 208 and the second peripheral surface 204 of the outer peripheral surface 54 of the circular cylindrical body 51A. However, this is only an example and should not be construed as limiting. For example, as shown in FIG. 17, a sensor 1F may include an airflow control portion 201A having a taper part 204A formed into a curved shape, when viewed in the cross section of the airflow control portion 201A in the vertical direction. In the sensor 1F shown in FIG. 17, the surface of the taper part 204A is curved. Thus, steam (having a greater inertial force, but a smaller diffusion force than those of smoke) is further suppressed from entering the sensor from the opening 510, compared with the second embodiment. Specifically, as shown in FIG. 17, the airflow control portion 201A divides a channel to a flow channel 69C through which smoke or steam mainly flows and a flow channel 69D. The airflow control portion 201A restricts the airflow such that a ratio of smoke in the flow channel 69D flowing into the opening 510 with respect to smoke in the flow channel 69C (as the main airflow) is made higher than a ratio of steam in the flow channel 69D flowing into the opening 510 with respect to steam in the flow channel 69C (as the main airflow). Therefore, the airflow control portion 201A can suppress the erroneous alarm of the sensor 1D by the steam.

[0169] In the second embodiment, the airflow control portion 201 and the opening 510 are provided. However, this is only an example and should not be construed as limiting. As shown in FIG. 18, a sensor 1G may include an opening 510A having a restriction part 206 provided to extend vertically upward from a lower end of the opening 510A. The restriction part 206 is provided to protrude vertically upward from the lower end of the opening 510A to restrict the airflow entering the sensor from the opening 510A. Thus, steam (having a greater inertial force, but a smaller diffusion force than those of smoke) is further suppressed from entering the sensor from the opening 510A, compared with the second embodiment. Specifically, in the gas flow channel 6 separated to a flow channel 69E (as a main airflow for gas) and a flow channel 69F, the restriction part 206 restricts the gas entering the sensor 1G through the separated flow channel 69F. The airflow control portion 201 controls the airflow such that a ratio of the smoke in the separated flow channel 69F with respect to the smoke when the smoke is included in the flow channel 69E (as the main airflow) is made higher than a ratio of the steam in the separated flow channel 69F with respect to the steam when the steam is included in the flow channel 69E (as the main airflow). The restriction part 206 can further reduce the amount of the steam, and accordingly, restrict the airflow such that a ratio of the amount of the smoke included in the flow channel 69F is made more than a ratio of the amount of the steam included in the flow channel 69F. In FIG. 18, the restriction part 206 has a rectangle, as a cross-sectional shape in the vertical direction. However, this is only an example and should not be construed as limiting. The cross-sectional shape of the restriction part 206 in the vertical direction may be a square, a trapezoid, a triangle, or a semicircle, for example.

(6) Recapitulation

[0170] As can be seen from the foregoing description, a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a first aspect includes a smoke detection chamber (4), an opening (510, 510A) and a dividing portion (Z1). The smoke detection chamber (4) has an inlet port (40) through which smoke flows into the smoke detection chamber (4). The opening (510, 510A) connects an external space (SP2) and a space (SP1) surrounding the smoke detection chamber (4). The dividing portion (Z1) is disposed in the space (SP1) surrounding the smoke detection chamber (4) to divide a gas flow channel (6). The dividing portion (Z1) is configured to divide the gas flow channel (6) such that a first ratio is made higher than a second ratio. The first ratio is a ratio of an amount of smoke reaching the inlet port (40) with respect to a first inflow of smoke flowing into the gas flow channel (6) through the opening (510, 510A). The second ratio is a ratio of an amount of steam reaching the inlet port (40) with respect to a second inflow of steam flowing into the gas flow channel (6) through the opening (510, 510A). According to the first aspect, the sensor can reduce the chance that erroneous detection occurs.

[0171] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a second aspect, which may be implemented in conjunction with the first aspect, the dividing portion (Z1) includes a branching part (71, 71A, 71B). The branching part (71, 71A, 71B) is configured to divide the space (SP1) surrounding the smoke detection chamber (4) into two areas in a separation direction (A1) including a component of a vertical direction (A2) so as to branch (divide) the gas flow channel (6) into an upside flow channel (61) and a downside flow channel (62). The branching part (71, 71A, 71B) is further configured to cause smoke flowing through the upside flow channel (61), of the upside flow channel (61) and the downside flow channel (62), to flow into the smoke detection chamber (4) from the inlet port (40). According to the second aspect, the sensor can further reduce the chance that the erroneous detection occurs.

[0172] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a third aspect, which may be implemented in conjunction with the second aspect, further includes a blocking part (72) disposed between the downside flow channel (62) and the smoke detection chamber (4) and configured to block steam flowing through the downside flow channel (62) from flowing into the smoke detection chamber (4). According to the third aspect, the sensor can further reduce the chance that the steam flows into the smoke detection chamber (4), and therefore can further reduce the chance that the erroneous detection occurs.

[0173] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a fourth aspect, which may be implemented in conjunction with the second or third aspect, the branching part (71, 71A, 71B) is provided around an entire circumference of the smoke detection chamber (4). According to the fourth aspect, the sensor can reduce the chance that the steam flows into the smoke detection chamber (4), even if the steam enters the sensor (1, 1A, 1B, 1C) from any direction of 360°, and therefore can further reduce the chance that the erroneous detection occurs.

[0174] In a sensor (1, 1A, 1B, 1C) according to a fifth aspect, which may be implemented in conjunction with any one of the second to fourth aspects, the smoke detection chamber (4) has a peripheral wall (41) including: a first region (411) in which the inlet port (40) is provided; and a second region (412) in which no inlet port (40) is provided. The branching part (71, 71A, 71B) has a recessed part (73) disposed in a position of facing the second region (412). According to the fifth aspect, the sensor can reduce the chance that the smoke, which has entered the sensor (1, 1A, 1B, 1C) toward the second region (412), hardly flows into the smoke detection chamber (4).

[0175] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, the dividing portion (Z1) is provided to divide the gas flow channel (6) to a first space (SP3), a second space (SP4) and a third space (SP5). The opening (510, 510A) and the first space (SP3) are adjacent to each other in one direction directed from the opening (510, 510A) to the smoke detection chamber (4), the first space (SP3) and the second space (SP4) are adjacent to each other in the one direction, and the second space (SP4) and the third space (SP5) are adjacent to each other in the one direction. Regarding the first inflow of smoke and the second inflow of steam, the first ratio of smoke is made higher than the second ratio of steam in the third space (SP5). The second space (SP4) has a larger volume than that of each of the first space (SP3) and the third space (SP5). According to the sixth aspect, the second space (SP4) has a larger volume than that of each of the first space (SP3) and the third space (SP5), which can promote formation of vortex flow of the gas including the smoke, the steam or both of the smoke and the steam, which has flowed into the second space (SP4).

[0176] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a seventh aspect, which may be implemented in conjunction with any one of the first to sixth aspects, the dividing portion (Z1) is provided to divide the gas flow channel (6) to a first space (SP3), a second space (SP4) and a third space (SP5). The opening (510, 510A) and the first space (SP3) are adjacent to each other in one direction directed from the opening (510, 510A) to the smoke detection chamber (4), the first space (SP3) and the second space (SP4) are adjacent to each other in the one direction, and the second space (SP4) and the third space (SP5) are adjacent to each other in the one direction. Regarding the first inflow of smoke and the second inflow of steam, the first ratio of smoke is made higher than the second ratio of steam in the third space (SP5). The second space (SP4) has a larger cross-sectional area than that of each of the first space (SP3) and the third space (SP5), in cross section taken along a plane including the one direction (directed from the opening (510) to the smoke detection chamber (4)), of the dividing portion (Z1), and a vertical direction (A2). According to the seventh aspect, the second space (SP4) has a larger cross-sectional area than that of each of the first space (SP3) and the third space (SP5), which can promote formation of vortex flow of the gas including the smoke, the steam or both of the smoke and the steam, which has flowed into the second space (SP4).

[0177] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to an eighth aspect, which may be implemented in conjunction with the sixth or seventh aspect, the second space in a vertical direction is longer than each of the first space (SP3) and the third space (SP5) in the vertical direction (A2), in cross section taken along a plane including the one direction (directed from the opening (510, 510A) to the smoke detection chamber (4)) and the vertical direction (A2). According to the eighth aspect, the length in the vertical direction, of the cross-sectional area of the second space (SP4), is longer than that of the cross-sectional area of each of the first space (SP3) and the third space (SP5), which can promote formation of vortex flow of the gas including the smoke, the steam or both of the smoke and the steam, which has flowed into the second space (SP4).

[0178] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a ninth aspect, which may be implemented in conjunction with any one of the sixth to eighth aspects, the second space (SP4) in the one direction is longer than each of the first space (SP3) and the third space (SP5) in the one direction, in cross section taken along a plane including the one direction (directed from the opening (510, 510A) to the smoke detection chamber (4)) and a vertical direction (A2). According to the ninth aspect, the length in the one direction (directed from the opening (510, 510A) to the smoke detection chamber (4)), of the cross-sectional area of the second space (SP4), is longer than the length in the radial direction, of the cross-sectional area of each of the first space (SP3) and the third space (SP5) in the radial direction, which can promote formation of vortex flow of the gas including the smoke, the steam or both of the smoke and the steam, which has flowed into the second space (SP4).

[0179] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a tenth aspect, which may be implemented in conjunction with any one of the sixth to ninth aspects, the dividing portion (Z1) has a sloped surface (203, 203A), which is disposed between the second space (SP4) and the third space (SP5) and sloped to extend vertically upward in the one direction. According to the tenth aspect, the dividing portion (Z1) has the sloped surface (203, 203A), which can promote formation of vortex flow of the gas including the smoke, the steam or both of the smoke and the steam, which has flowed into the second space (SP4).

[0180] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to an eleventh aspect, which may be implemented in conjunction with any one of the first to tenth aspects, further includes an airflow control portion (201, 201A) disposed over an outer periphery of the opening (510, 510A) in a vertical direction and configured to control gas so as to flow in the opening (510, 510A). According to the eleventh aspect, the airflow control portion (201, 201A) can restrict the gas flow channel (6). Therefore, regarding a ratio of the smoke and the steam in the gas flowing in the opening (510, 510A), a ratio of the smoke can be increased, compared with that in the gas before flowing in the opening.

[0181] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a twelfth aspect, which may be implemented in conjunction with the eleventh aspect, the airflow control portion (201, 201A) is configured to separate a main airflow including smoke or steam in the external space (SP2) to: a first airflow not flowing into the gas flow channel (6) from the opening (510, 510A); and a second airflow flowing into the gas flow channel (6) from the opening (510, 510A). The airflow control portion (201, 201A) is configured to control the main airflow such that a ratio of an amount of the smoke in the second airflow with respect to an amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than a ratio of an amount of the steam in the second airflow with respect to an amount of the steam in the first airflow when the main airflow includes the steam. According to the twelfth aspect, the airflow control portion (201, 201A) is configured to separate the main airflow to the first airflow and the second airflow, and control the main airflow such that a ratio of an amount of the smoke in the second airflow with respect to an amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than a ratio of an amount of the steam in the second airflow with respect to an amount of the steam in the first airflow when the main airflow includes the steam, which can suppress occurrence of erroneous detection due to the steam.

[0182] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a thirteenth aspect, which may be implemented in conjunction with any one of the first to twelfth aspects, further includes a base (2, 2A) on which the smoke detection chamber (4) is mounted. According to the twelfth aspect, the occurrence of erroneous detection can be reduced in the sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G) where the smoke detection chamber (4) is mounted on the base (2, 2A).

[0183] In a sensor (1, 1A, 1B, 1C) according to a fourteenth aspect, which may be implemented in conjunction with the thirteenth aspect, the base (2, 2A) is a circuit board. According to the fourteenth aspect, the sensor can contribute to further reducing the number of components, compared with, for example, a case that the base (2, 2A) is provided as another member separately from a circuit board.

[0184] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a fifteenth aspect, which may be implemented in conjunction with the thirteenth or fourteenth aspect, further includes one or more heat sensitive elements (30) disposed on an outer peripheral part (23) of the base (2, 2A). According to the fifteenth aspect, the occurrence of erroneous detection can be reduced in the sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) further having a function of sensing heat.

[0185] In a sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a sixteenth aspect, which may be implemented in conjunction with the fifteenth aspect, the outer peripheral part (23) of the base has a recess (24) disposed around a region at which each of the one or more heat sensitive elements (30) is disposed, the recess (24) being recessed inward. According to the sixteenth aspect, the sensor can improve the heat flow with respect to the one or more heat sensitive elements (30).

[0186] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a seventeenth aspect, which may be implemented in conjunction with any one of the thirteenth to sixteenth aspects, further includes a tubular portion (511) disposed to cover a lower surface (second surface 22) of the base (2, 2A). The base (2, 2A) has a protruded edge (25) protruded outward from the tubular portion (511). According to the seventeenth aspect, the protruded edge (25) can reduce the chance that the steam flows through the upside flow channel (61).

[0187] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to an eighteenth aspect, which may be implemented in conjunction with any one of the thirteenth to seventeenth aspects, further includes a lower cover (51). The lower cover (51) has the opening (510) connecting the external space (SP2) and the space (SP1) surrounding the smoke detection chamber (4), and is disposed under the base (2, 2A). An outer peripheral part (23) of the base (2, 2A) is disposed not to be protruded to the external space (SP2) from the opening (510), when viewed from front of the lower cover (51). According to the eighteenth aspect, the sensor can reduce the chance that the outer peripheral part (23) of the base (2, 2A) prevents the smoke from entering the sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) through the opening (510).

[0188] A sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) according to a nineteenth aspect, which may be implemented in conjunction with any one of the first to eighteenth aspects, further includes an upper cover (52, 53) disposed to cover the smoke detection chamber (4) from above the smoke detection chamber (4). The dividing portion (Z1) includes a branching part (71, 71A, 71B). The branching part (71, 71A, 71B) is configured to divide the space (SP1) surrounding the smoke detection chamber (4) into two areas in a separation direction (A1) including a component of a vertical direction (A2) so as to branch the gas flow channel (6) into an upside flow channel (61) and a downside flow channel (62). The branching part (71, 71A, 71B) is further configured to cause smoke flowing through the upside flow channel (61), of the upside flow channel (61) and the downside flow channel (62), to flow into the smoke detection chamber (4) from the inlet port (40). The upper cover (52, 53) is disposed to form a part of the upside flow channel (61), of the upside flow channel (61) and the downside flow channel (62). According to the nineteenth aspect, the sensor can contribute to further reducing the number of components, compared with a case that a member forming the downside flow channel (62) is provided as another member separately from the upper cover (52). Also, the sensor can be more easily downsized (in particular, the thickness of the sensor can be reduced).

[0189] Note that the constituent elements according to the second to nineteenth aspects are not essential constituent elements for the sensor (1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H) but may be omitted as appropriate.

Reference Signs List

[0190]

1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H	Sensor
2, 2A	Base
202	Slope
22	Second Surface (Lower Surface)
23	Outer Peripheral Part
24	Recess
25	Protruded Edge
30	Heat Sensitive Element
4	Smoke Detection Chamber
40	Inlet Port
41	Peripheral Wall
411	First Region
412	Second Region
51	Lower Cover
510, 510A	Opening
511	Tubular Portion
52, 53	Upper Cover
6	Gas Flow Channel
61	Upside Flow Channel
62	Downside Flow Channel
71, 71A, 71B	Branching Part

72	Blocking Part
73	Recessed Part
A1	Separation Direction
A2	Vertical Direction
SP1	Space Surrounding Smoke Detection Chamber
SP2	External Space
SP3	First Space
SP4	Second Space
SP5	Third Space
Z1	Dividing Portion

Claims

1. A sensor, comprising:

   a smoke detection chamber having an inlet port through which smoke flows into the smoke detection chamber;
   an opening connecting an external space and a space surrounding the smoke detection chamber; and
   a dividing portion disposed in the space surrounding the smoke detection chamber to divide a gas flow channel, the dividing portion being configured to divide the gas flow channel such that a first ratio is made higher than a second ratio,
   the first ratio being a ratio of an amount of smoke reaching the inlet port with respect to a first inflow of smoke flowing into the gas flow channel through the opening, and
   the second ratio being a ratio of an amount of steam reaching the inlet port with respect to a second inflow of steam flowing into the gas flow channel through the opening.

2. The sensor of claim 1, wherein

   the dividing portion includes a branching part configured to divide the space surrounding the smoke detection chamber into two areas in a separation direction including a component of a vertical direction so as to branch the gas flow channel into an upside flow channel and a downside flow channel, and
   the branching part is further configured to cause smoke flowing through the upside flow channel, of the upside flow channel and the downside flow channel, to flow into the smoke detection chamber from the inlet port.

3. The sensor of claim 2, further comprising a blocking part disposed between the downside flow channel and the smoke detection chamber and configured to block steam flowing through the downside flow channel from flowing into the smoke detection chamber.

4. The sensor of claim 2 or 3, wherein
   the branching part is provided around an entire circumference of the smoke detection chamber.

5. The sensor of any one of claims 2 to 4, wherein

   the smoke detection chamber has a peripheral wall including:

      a first region in which the inlet port is provided; and
      a second region in which no inlet port is provided, and

   the branching part has a recessed part disposed in a position of facing the second region.

6. The sensor of any one of claims 1 to 5, wherein

   the dividing portion is provided to form, as the gas flow channel, a first space, a second space and a third space,
   the external space and the first space are adjacent to each other in one direction directed from the opening to the smoke detection chamber, the first space and the second space being adjacent to each other in the one direction, and the second space and the third space being adjacent to each other in the one direction,
   regarding the first inflow of smoke and the second inflow of steam, the first ratio of smoke is made higher than the second ratio of steam in the third space, and

the second space has a larger volume than that of each of the first space and the third space.

7. The sensor of any one of claims 1 to 6, wherein

the dividing portion is provided to form, in the gas flow channel, a first space, a second space and a third space, the external space and the first space are adjacent to each other in one direction directed from the opening to the smoke detection chamber, the first space and the second space being adjacent to each other in the one direction, and the second space and the third space being adjacent to each other in the one direction,
regarding the first inflow of smoke and the second inflow of steam, the first ratio of smoke is made higher than the second ratio of steam in the third space, and
the second space has a larger cross-sectional area than that of each of the first space and the third space, in cross section taken along a plane including the one direction and a vertical direction.

8. The sensor of claim 6 or 7, wherein
the second space in a vertical direction is longer than each of the first space and the third space in the vertical direction, in cross section taken along a plane including the one direction and the vertical direction.

9. The sensor of any one of claims 6 to 8, wherein
the second space in the one direction is longer than each of the first space and the third space in the one direction, in cross section taken along a plane including the one direction and a vertical direction.

10. The sensor of any one of claims 6 to 9, wherein
the dividing portion has a sloped surface, which is disposed between the second space and the third space and sloped to extend vertically upward as closer to the smoke detection chamber in the one direction.

11. The sensor of any one of claims 1 to 10, further comprising an airflow control portion disposed over an outer periphery of the opening in a vertical direction and configured to control gas so as to flow in the opening.

12. The sensor of claim 11, wherein

the airflow control portion is configured to separate a main airflow including smoke or steam in the external space to:

a first airflow not flowing into the gas flow channel from the opening; and
a second airflow flowing into the gas flow channel from the opening, and

the airflow control portion is configured to control the main airflow such that a ratio of an amount of the smoke in the second airflow with respect to an amount of the smoke in the first airflow when the main airflow includes the smoke is made higher than a ratio of an amount of the steam in the second airflow with respect to an amount of the steam in the first airflow when the main airflow includes the steam.

13. The sensor of any one of claims 1 to 12, further comprising a base on which the smoke detection chamber is mounted.

14. The sensor of claim 13, wherein
the base is a circuit board.

15. The sensor of claim 13 or 14, further comprising one or more heat sensitive elements disposed on an outer peripheral part of the base.

16. The sensor of claim 15, wherein
the outer peripheral part of the base has a recess disposed around a region at which each of the one or more heat sensitive elements is disposed, the recess being recessed inward.

17. The sensor of any one of claims 13 to 16, further comprising a tubular portion disposed to cover a lower surface of the base, wherein
the base has a protruded edge protruded outward from the tubular portion.

18. The sensor of any one of claims 13 to 17, further comprising a lower cover having the opening connecting the

external space and the space surrounding the smoke detection chamber, the lower cover being disposed under the base, wherein
an outer peripheral part of the base is disposed not to be protruded to the external space from the opening, when viewed from front of the lower cover.

19. The sensor of any one of claims 1 to 18, further comprising an upper cover disposed to cover the smoke detection chamber from above the smoke detection chamber,

the dividing portion includes a branching part configured to divide the space surrounding the smoke detection chamber into two areas in a separation direction including a component of a vertical direction so as to branch the gas flow channel into an upside flow channel and a downside flow channel,
the branching part is further configured to cause smoke flowing through the upside flow channel, of the upside flow channel and the downside flow channel, to flow into the smoke detection chamber from the inlet port, and
the upper cover is disposed to form a part of the upside flow channel, of the upside flow channel and the downside flow channel.

FIG. 1

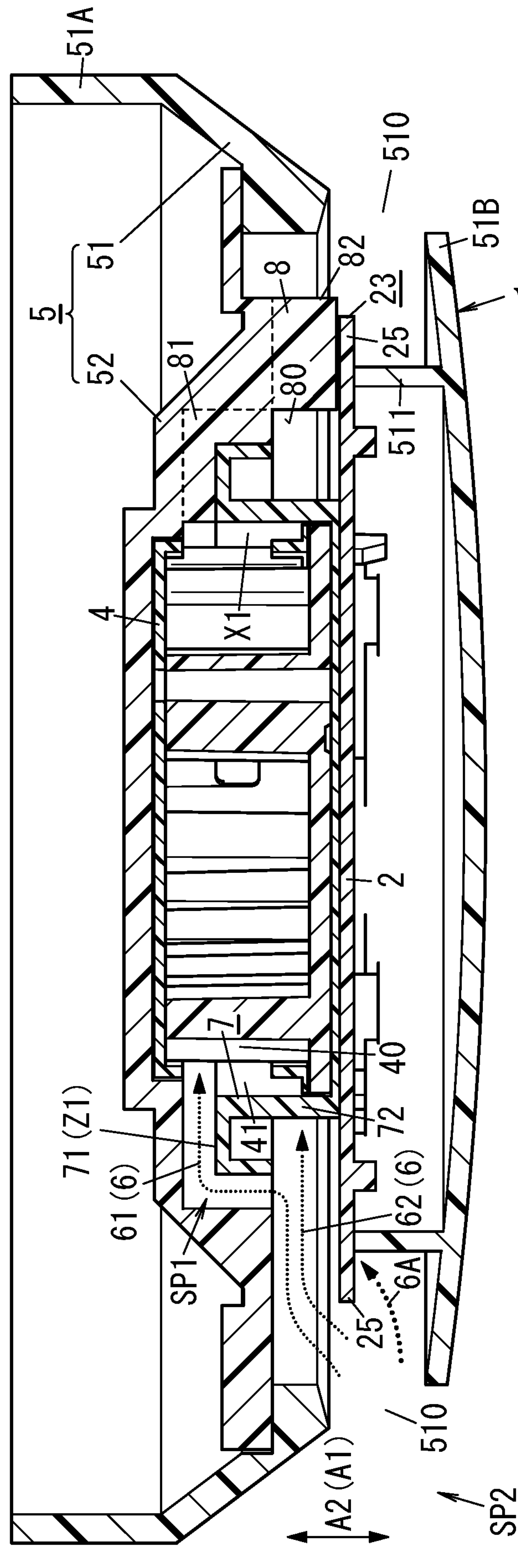

51A
510
51B
1
51
5
52
8
82
23
25
81
80
511
4
X1
2
7
40
71 (Z1)
41
72
61 (6)
62 (6)
SP1
6A
25
510
A2 (A1)
SP2

FIG. 2

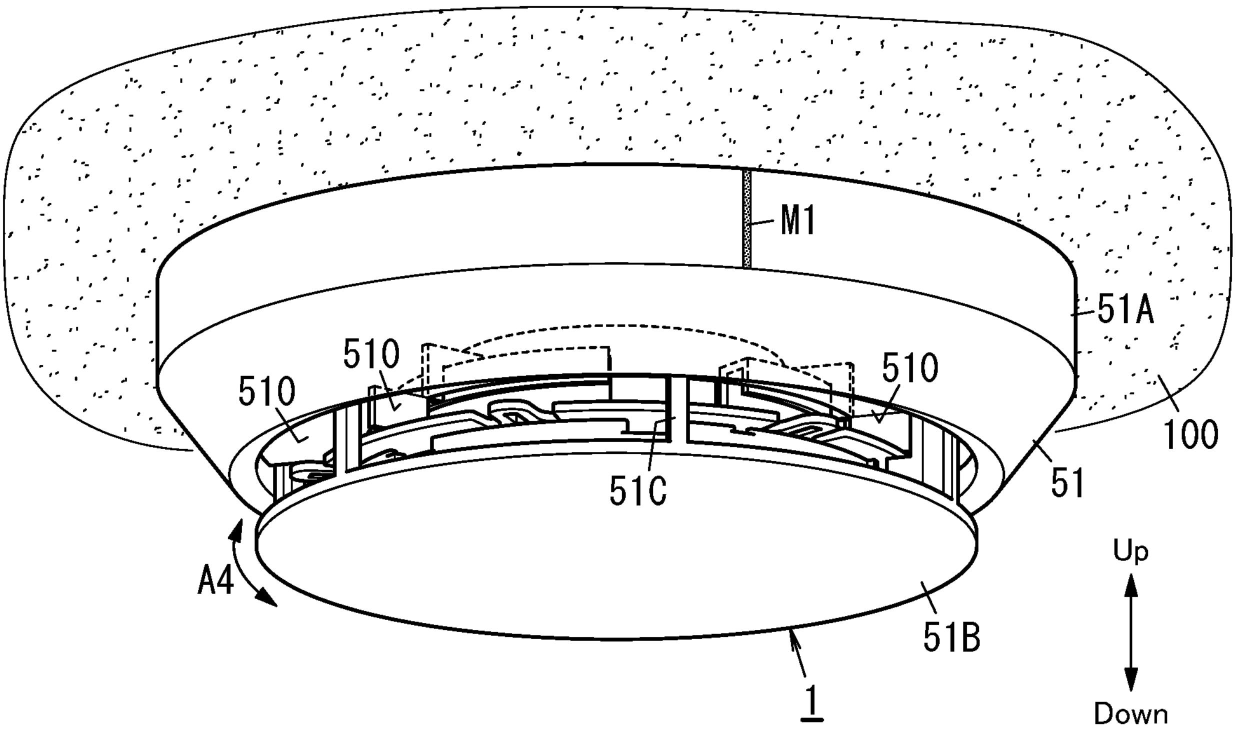


FIG. 3

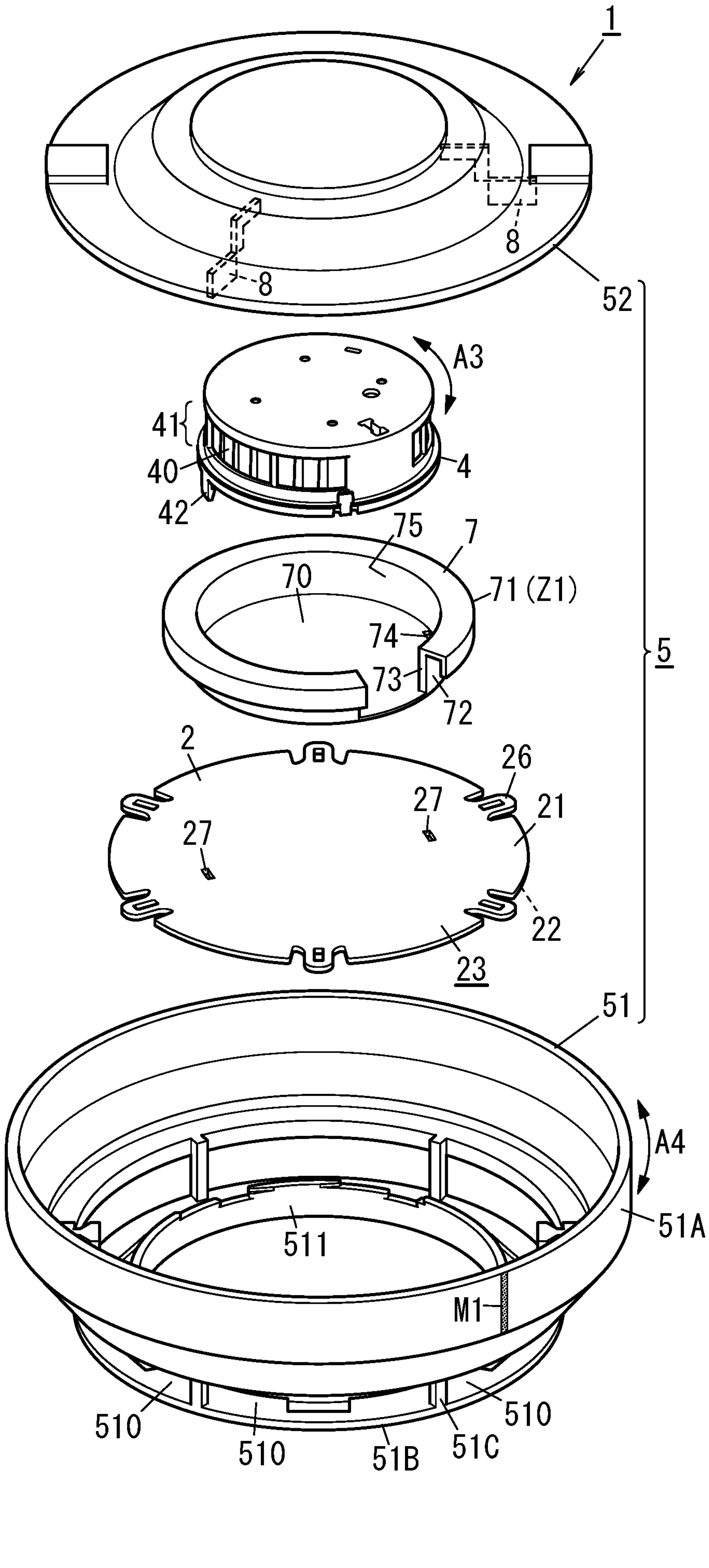
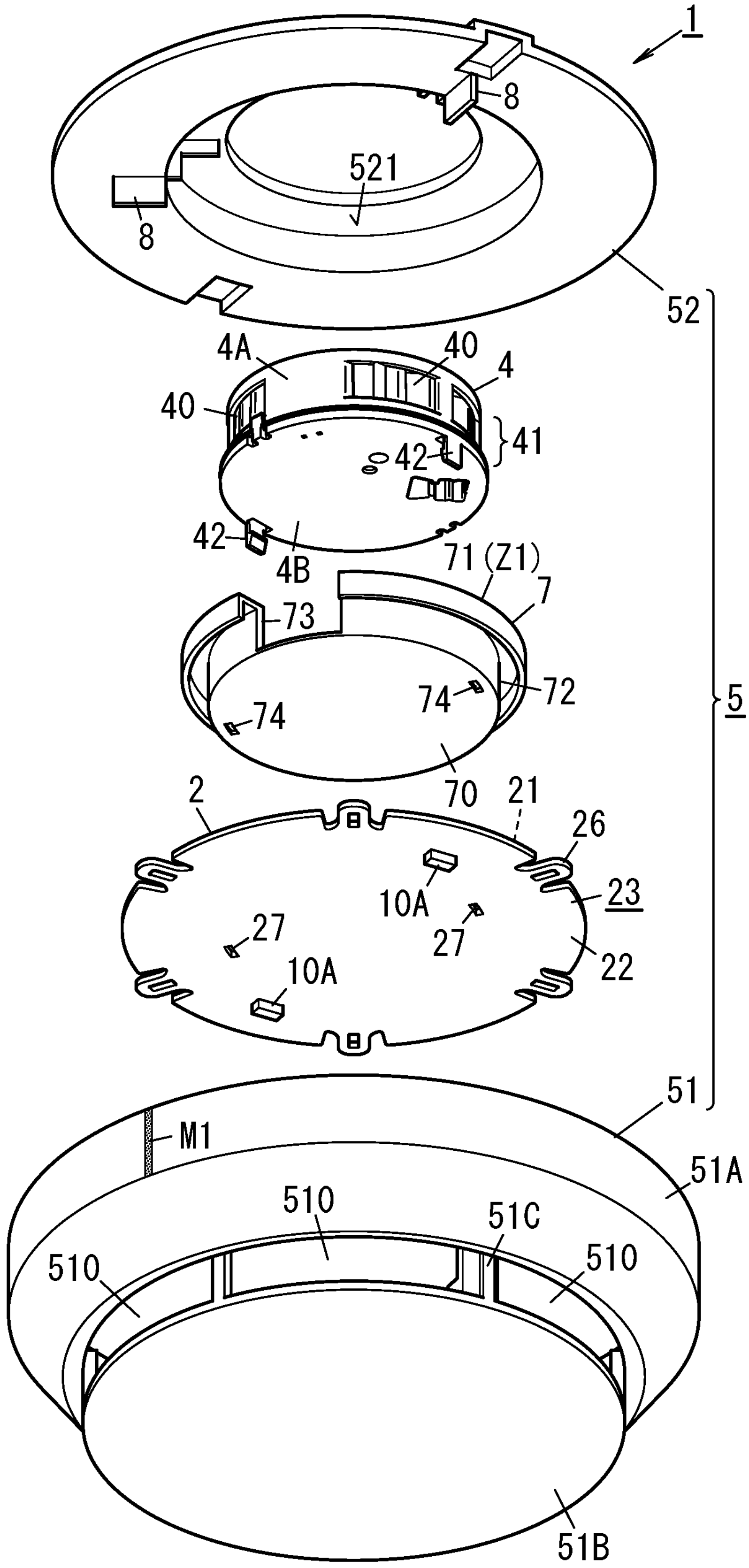

1
8
8
52
A3
41
40
4
42
75
7
70
71(Z1)
74
73
72
5
2
26
27
21
27
22
23
51
A4
511
51A
M1
510
510
510
51B
51C

FIG. 4


1
8
521
8
52
4A
40
4
40
41
42
42
4B
71 (Z1)
7
73
74
72
74
70
5
2
21
26
23
10A
27
27
22
10A
51
M1
51A
510
51C
510
510
51B

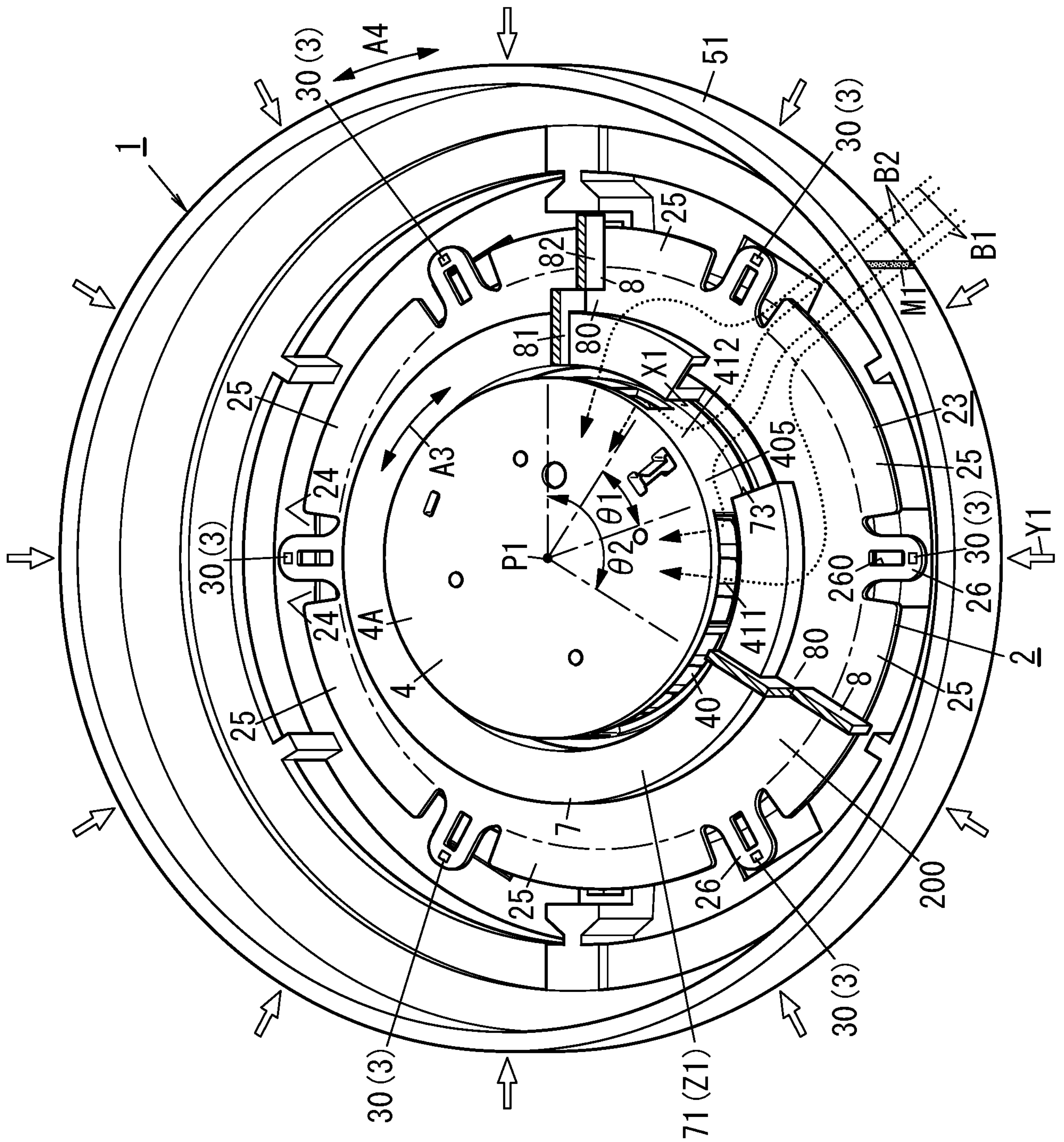

1
A4
30 (3)
51
B2
B1
M1
25
82
8
81
80
X1
412
A3
24
θ1
405
73
23
P1
θ2
260
26
Y1
4A
411
4
40
2
200
7
71 (Z1)

FIG. 5

FIG. 6

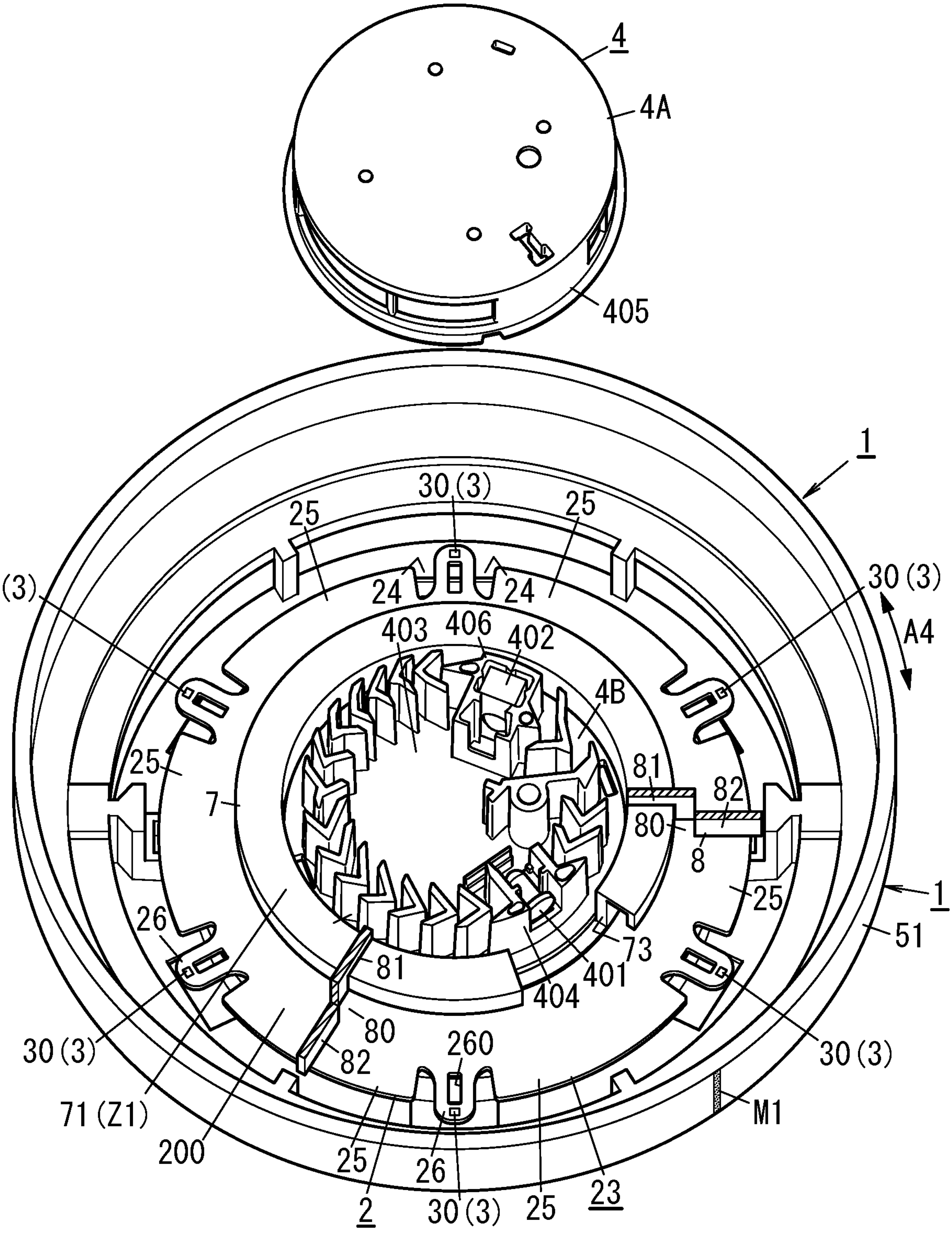

4
4A
405
1
30(3)
25
25
24
24
30(3)
30(3)
A4
403
406
402
4B
25
81
82
7
80
8
25
1
51
26
81
73
401
404
30(3)
80
82
260
30(3)
71(Z1)
200
25
26
M1
2
30(3)
25
23

FIG. 7

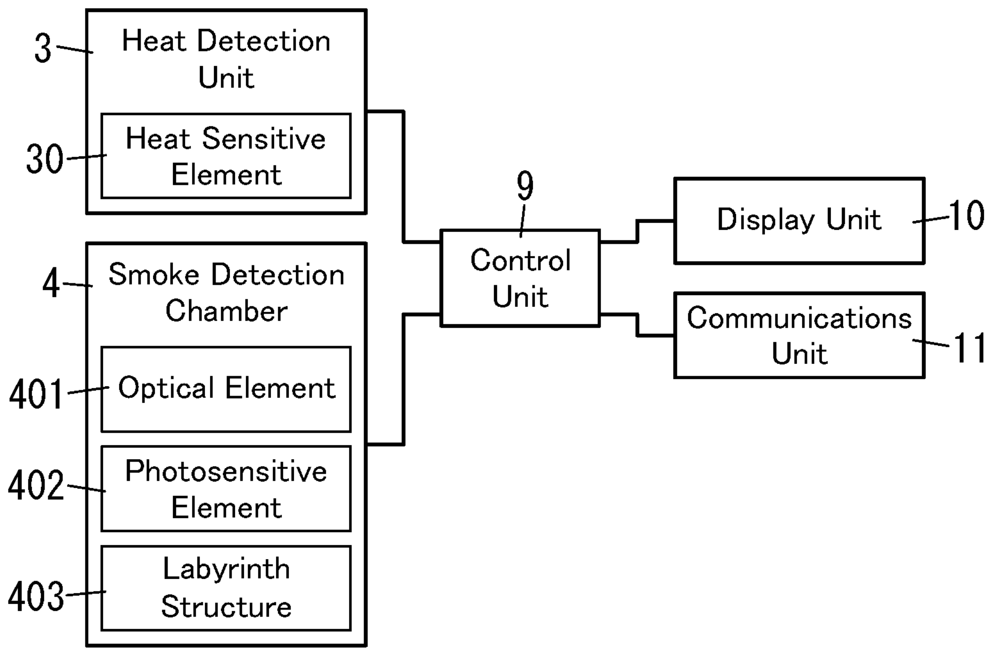

3
Heat Detection Unit
30
Heat Sensitive Element
4
Smoke Detection Chamber
401
Optical Element
402
Photosensitive Element
403
Labyrinth Structure
9
Control Unit
Display Unit
10
Communications Unit
11

FIG. 8

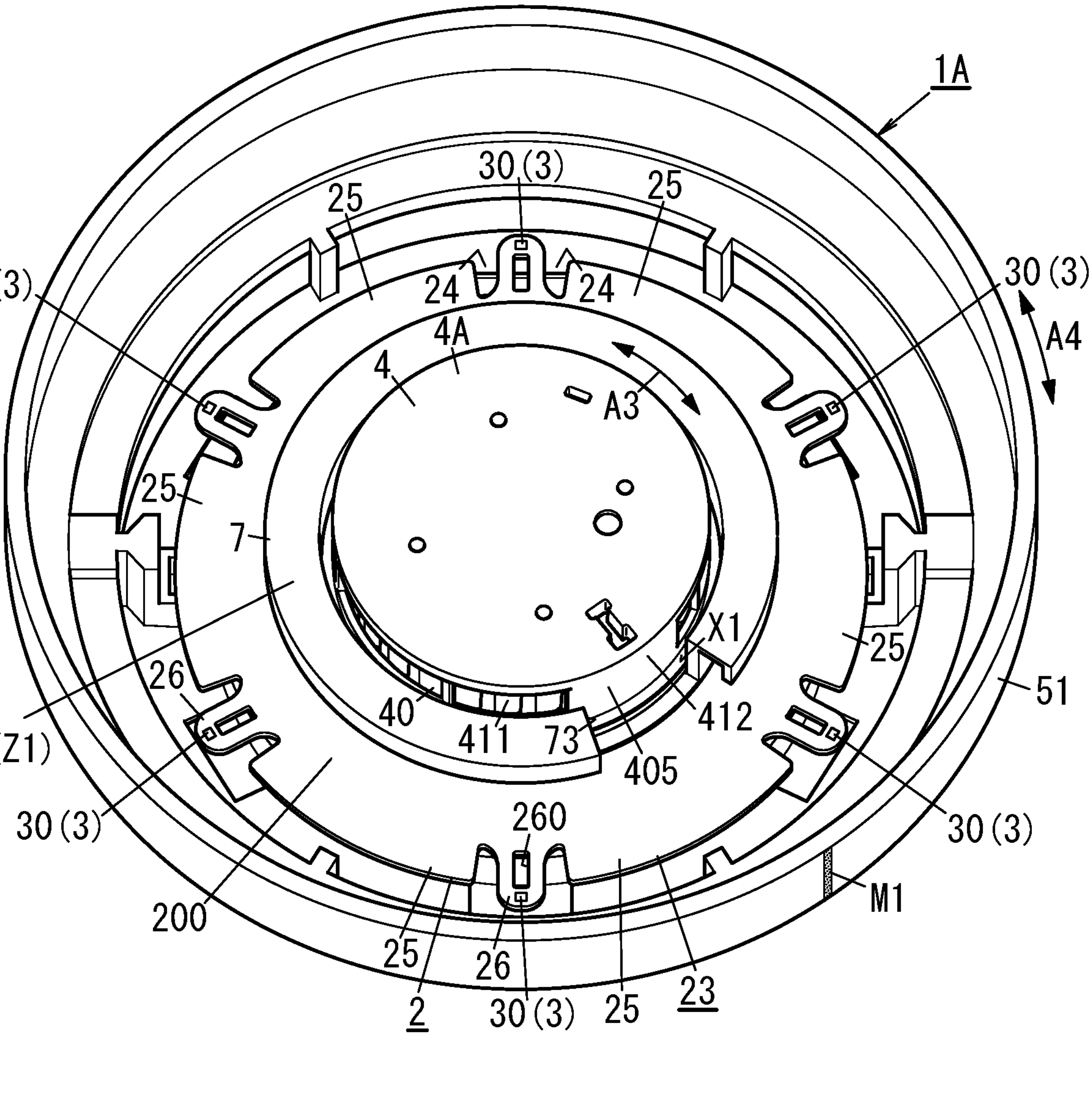
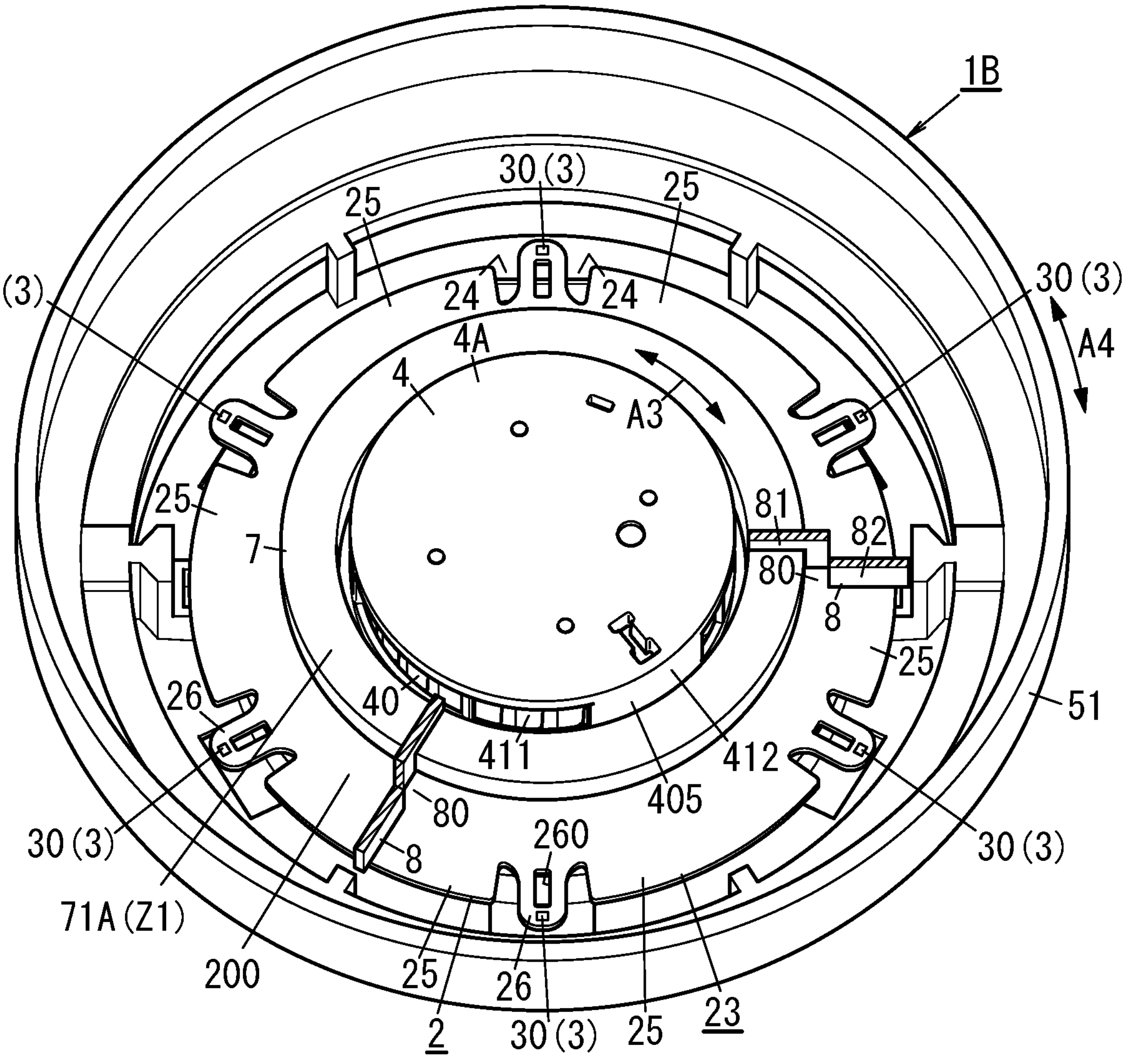

1A
30 (3)
25
25
24
24
30 (3)
30 (3)
A4
4A
4
A3
25
7
X1
25
51
26
71 (Z1)
40
411
73
412
405
30 (3)
30 (3)
260
M1
200
25
26
2
30 (3)
25
23

FIG. 9


1B
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25
30 (3)
30 (3)
24
24
A4
4A
4
A3
25
81
82
7
80
8
25
26
40
411
412
51
405
80
260
30 (3)
8
30 (3)
71A (Z1)
200
25
26
25
23
2
30 (3)
25

FIG. 10

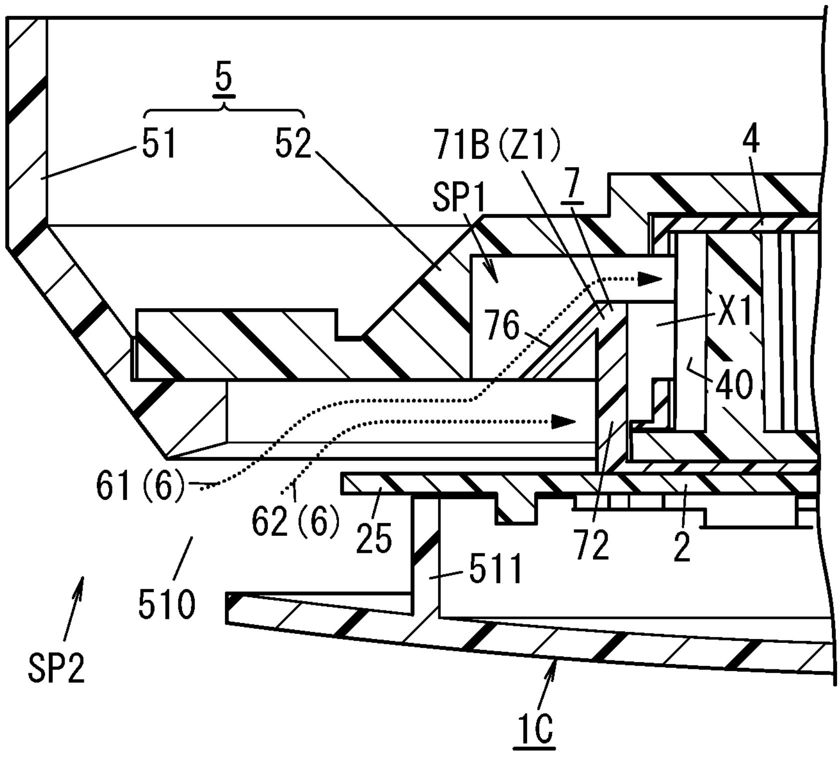


FIG. 11

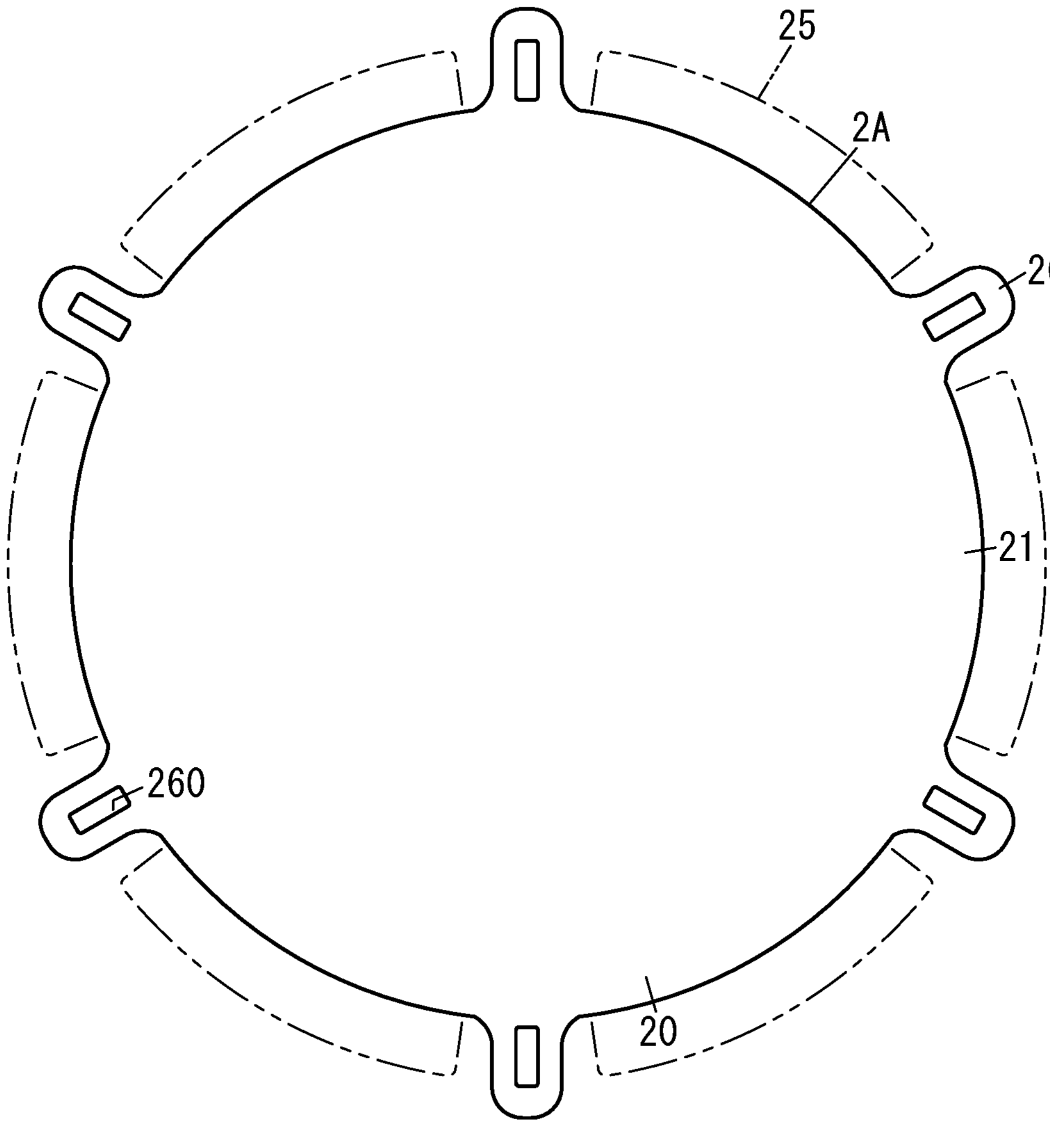
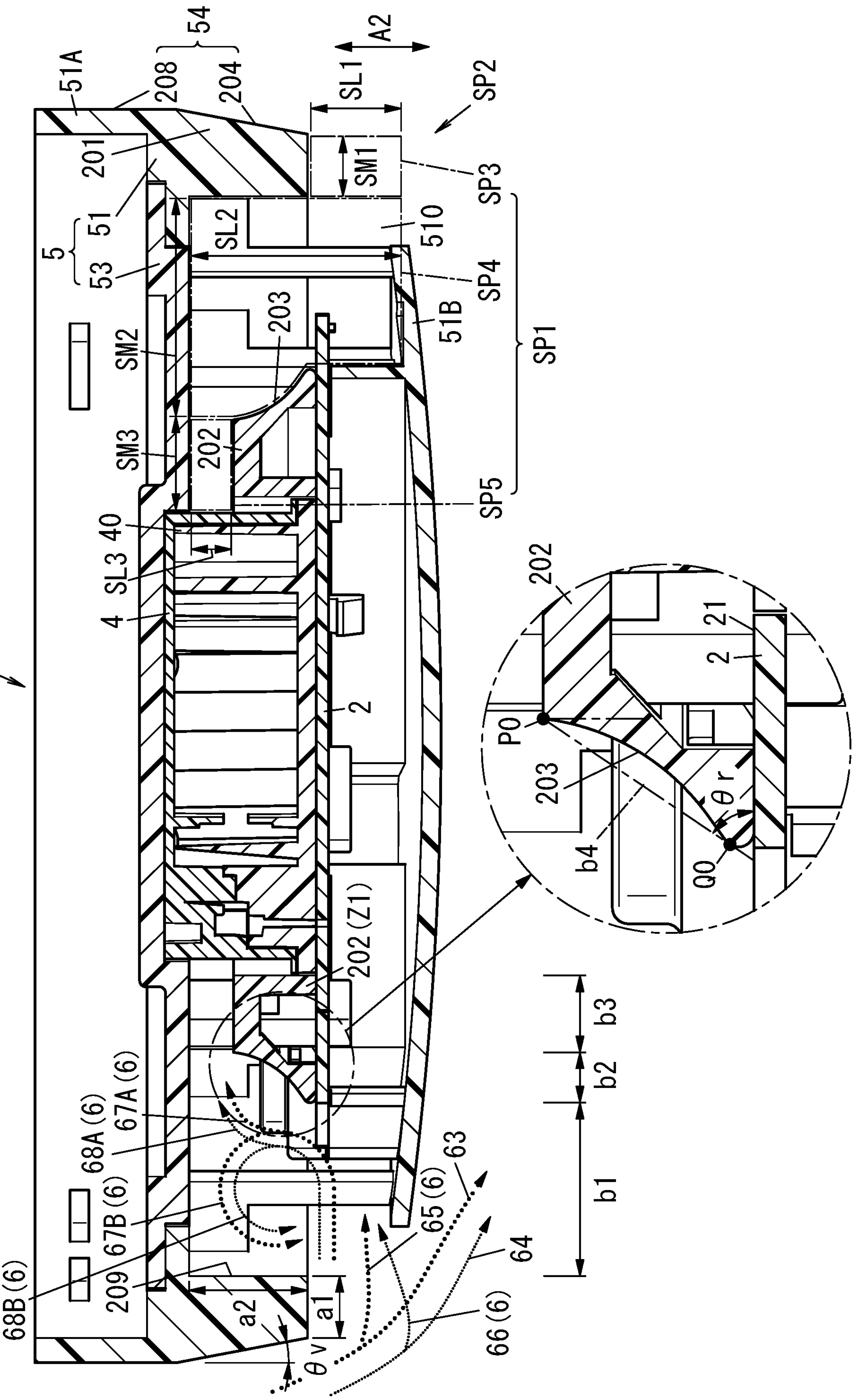
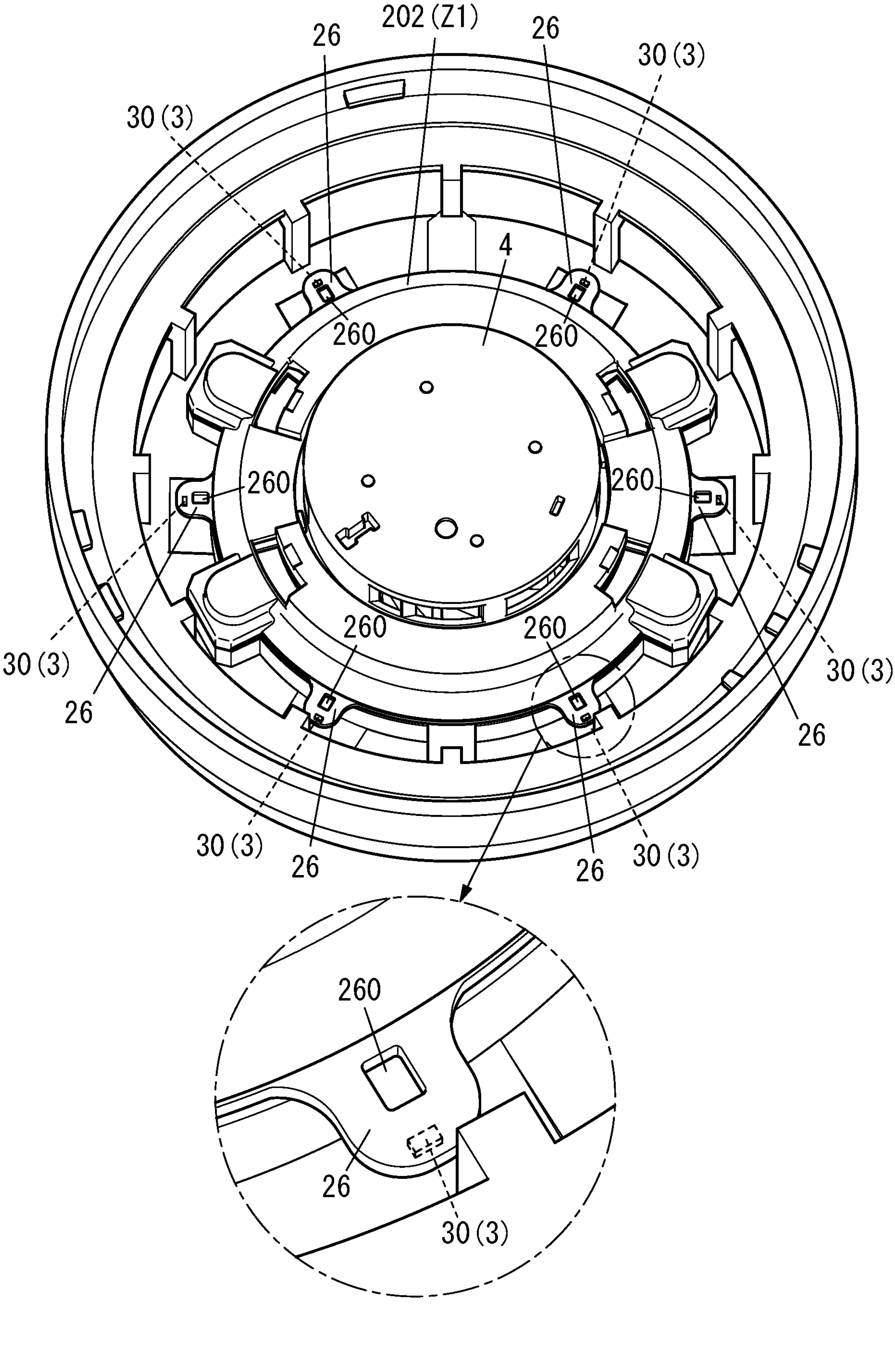


FIG. 12



1D
51A
208
54
204
A2
SL1
SP2
201
51
SM1
SP3
5
53
SL2
510
SP4
51B
203
SP1
SM2
SM3
202
SP5
40
SL3
4
2
21
P0
203
θr
b4
Q0
202(Z1)
b3
b2
67A(6)
68A(6)
b1
68B(6)
67B(6)
209
65(6)
63
64
a2
a1
θv
66(6)

FIG. 13



202 (Z1)
26
26
30 (3)
30 (3)
4
260
260
260
260
260
260
30 (3)
30 (3)
26
26
30 (3)
26
26
30 (3)
260
26
30 (3)

FIG. 14

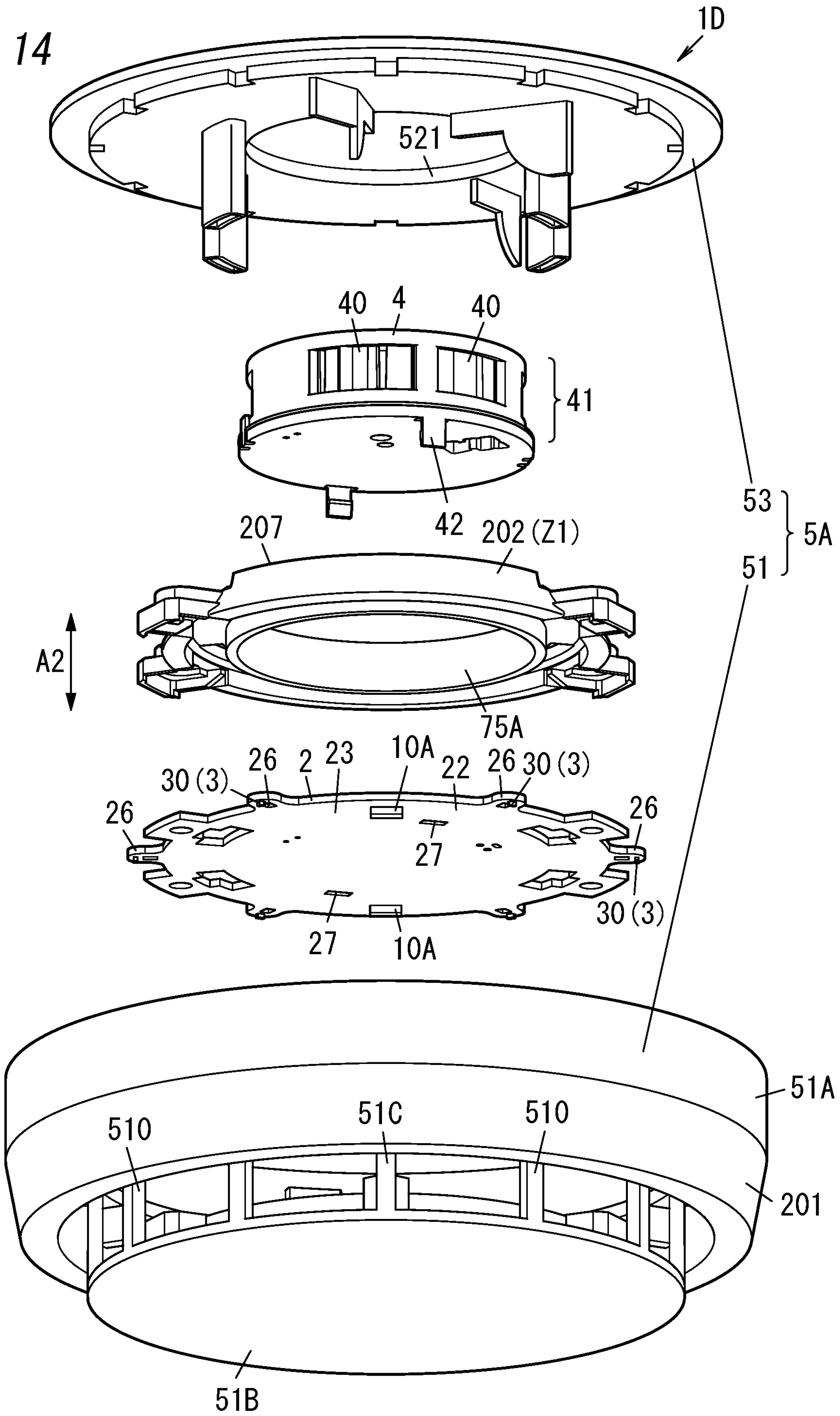

1D
521
40
4
40
41
42
53
5A
51
207
202 (Z1)
A2
75A
30 (3)
26
2
23
10A
22
26
30 (3)
26
26
27
30 (3)
27
10A
51A
510
51C
510
201
51B

FIG. 15A

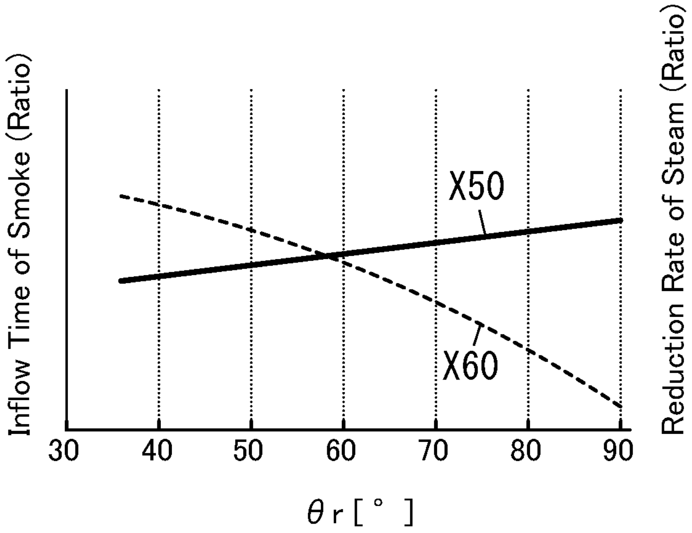


FIG. 15B

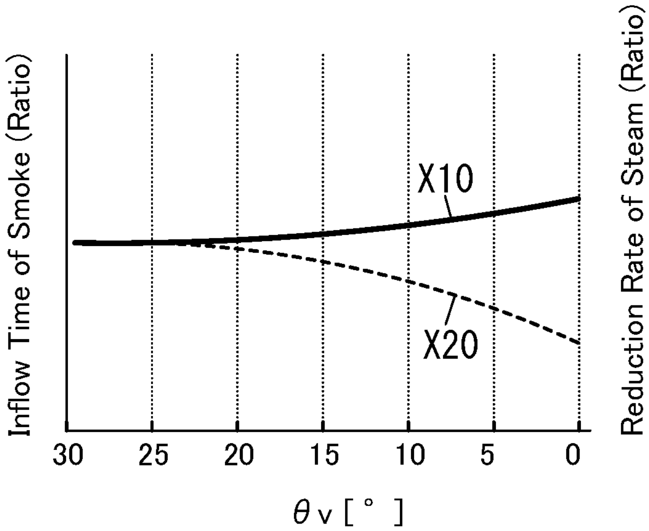


FIG. 15C

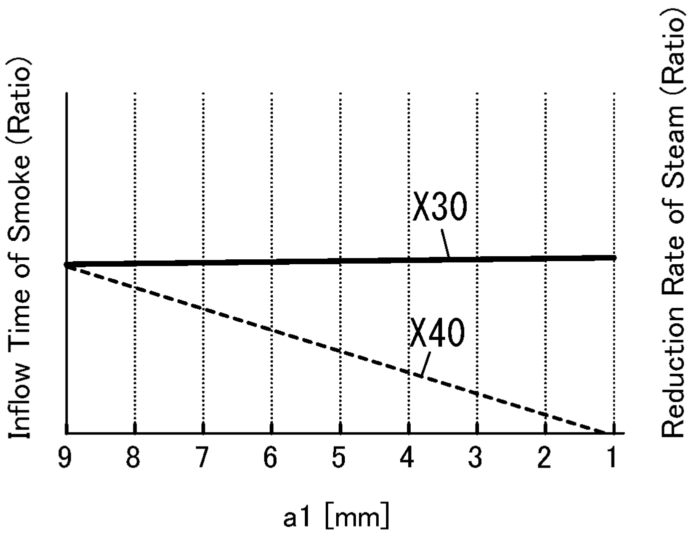


FIG. 16

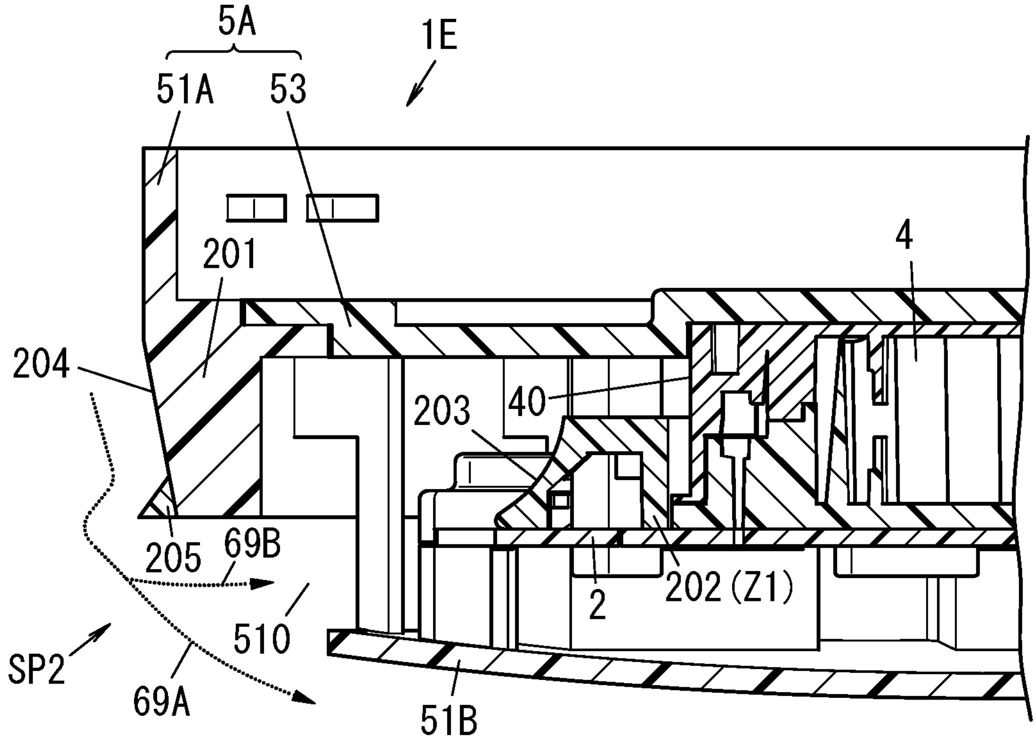


FIG. 17

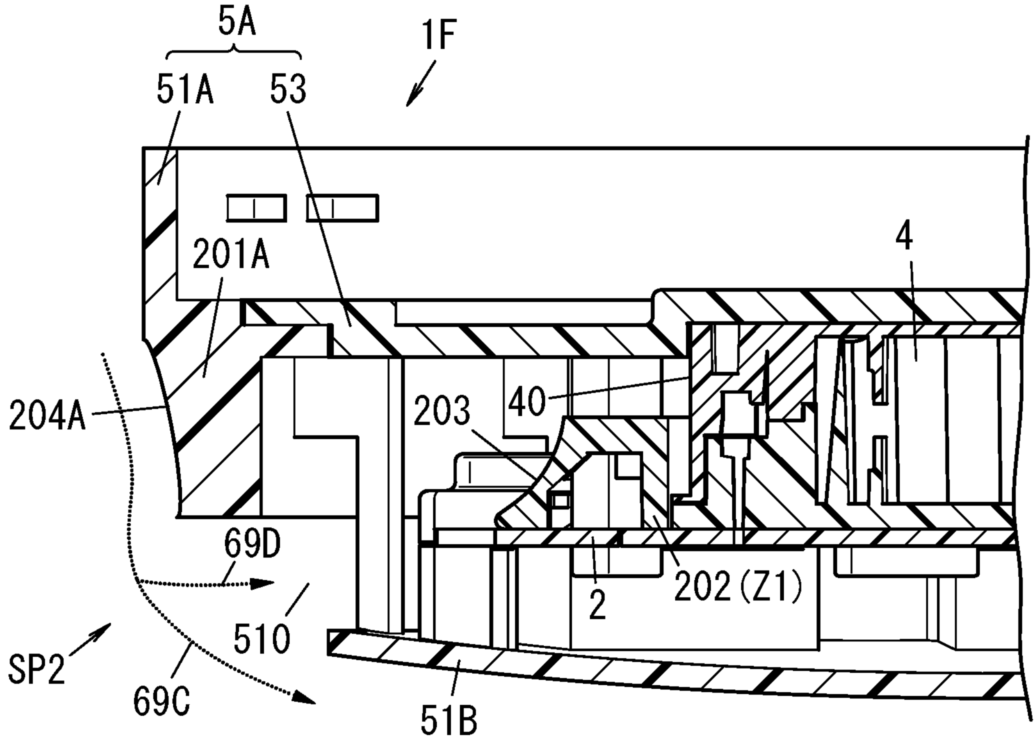


FIG. 18

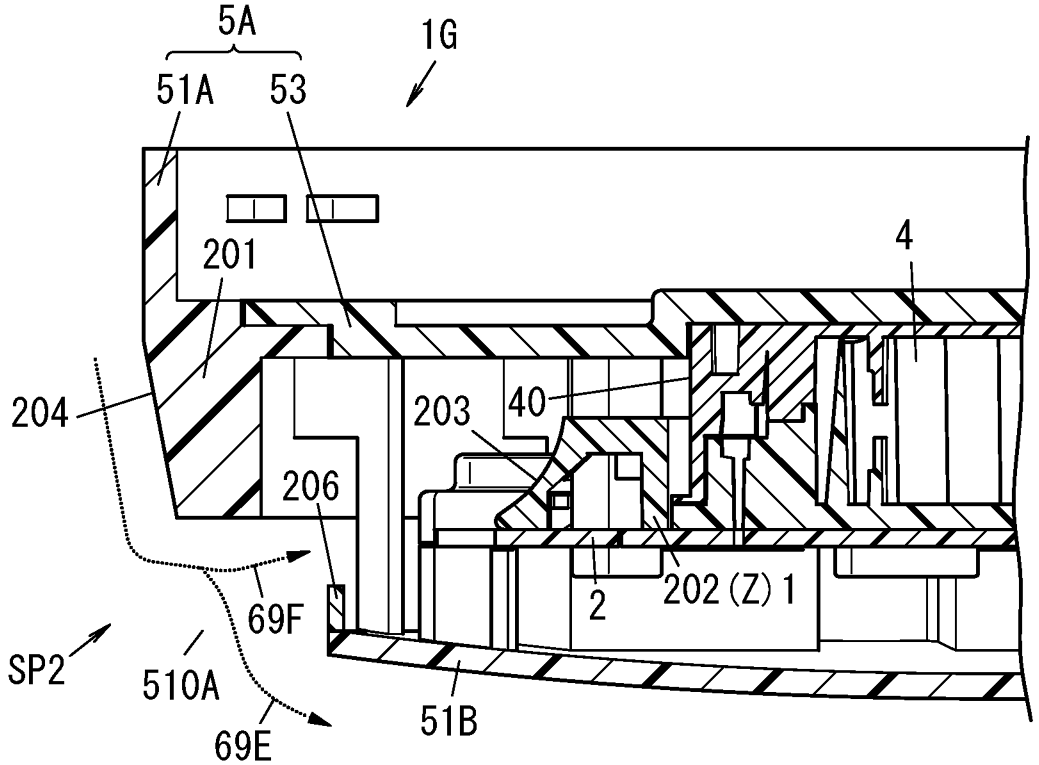
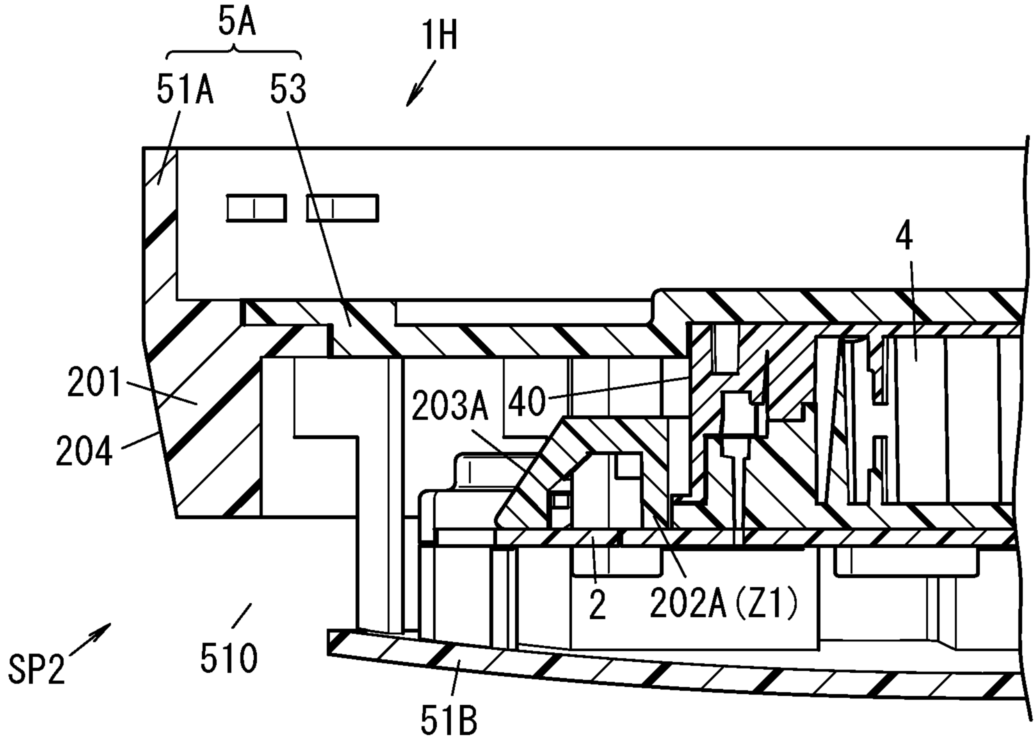


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/016125

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. G08B17/00(2006.01)i, G08B17/103(2006.01)i, G08B17/107(2006.01)i
FI: G08B17/107 A, G08B17/103 A, G08B17/00 G

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. G08B17/00, G08B17/103, G08B17/107

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2018-067067 A (NOHMI BOSAI LTD.) 26 April 2018, paragraphs [0025]-[0029], [0032]-[0037], fig. 7	1-4, 6, 9-13
Y	paragraphs [0025]-[0029], [0032]-[0037], fig. 7	5, 14-16, 18
A	paragraphs [0025]-[0029], [0032]-[0037], fig. 7	7-8, 17, 19
Y	JP 2005-293548 A (NOHMI BOSAI LTD.) 20 October 2005, paragraph [0025], fig. 6, 7 (b), 7 (c)	5
A	paragraph [0025], fig. 6, 7 (b), 7 (c)	1-4, 7-19
Y	WO 2020/075487 A1 (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 16 April 2020 paragraphs [0029]-[0043], fig. 1-3B, 6	14-16, 18
A	paragraph [0029]-[0043], fig. 1-3B, 6	1-13, 17, 19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13.05.2021	25.05.2021

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/016125

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2018-067067 A	26.04.2018	(Family: none)	
JP 2005-293548 A	20.10.2005	(Family: none)	
WO 2020/075487 A1	16.04.2020	JP 2020-61122 A paragraphs [0030]-[0044], fig. 1-3B, 6	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2012014330 A **[0004]**