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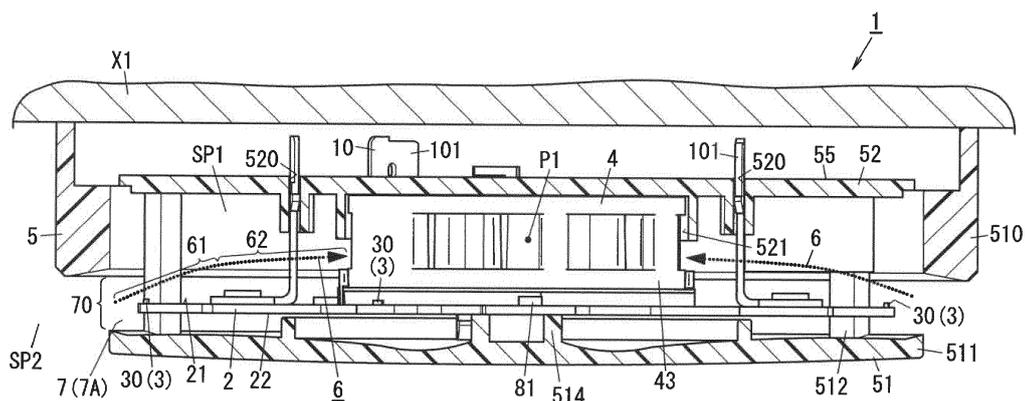
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(54) **SENSOR**

(57) An object of the present disclosure is to contribute to downsizing. A sensor (1) includes a board (2), a heat sensitive element (30), and a housing (5). The housing (5) houses the board (2). The housing (5) has a flow channel (6) provided in an internal space (SP1) thereof and allowing a gas to flow therethrough, and an opening

(7) connecting the flow channel (6) to an external space (SP2) outside of the housing (5). The heat sensitive element (30) is implemented as a chip thermistor mounted on the board (2) and detecting heat of the gas that has flowed in through the opening (7).

**FIG. 1**



**EP 3 866 130 A1**

## Description

### Technical Field

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

### Background Art

[0002] Patent Literature 1 discloses an exemplary known heat and smoke sensor. The sensor includes a heat sensing means for sensing heat and a smoke sensing unit 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.

[0003] In the sensor of Patent Literature 1, however, the heat sensitive element is provided at the upper end of the lead wire, thus possibly making it difficult to reduce the overall size (e.g., the thickness, among other things) of the sensor depending on the length of the lead wire.

### Citation List

#### Patent Literature

[0004] Patent Literature 1: JP 2012-014330 A

### Summary of Invention

[0005] In view of the foregoing background, it is therefore an object of the present disclosure to provide a sensor contributing to downsizing.

[0006] A sensor according to an aspect of the present disclosure includes a board, a heat sensitive element, and a housing. The housing houses the board. The housing has a flow channel provided in an internal space thereof and configured to allow a gas to flow there-through, and an opening connecting the flow channel to an external space outside of the housing. The heat sensitive element is implemented as a chip thermistor mounted on the board and configured to detect heat of the gas that has flowed in through the opening.

### Brief Description of Drawings

#### [0007]

FIG. 1 is a cross-sectional view of a sensor according to a first embodiment;  
 FIG. 2 is a perspective view of the sensor as viewed from below the sensor;  
 FIG. 3A is a plan view of the sensor, of which some constituent elements are seen through in phantom lines;  
 FIG. 3B is an enlarged plan view of a principal part

thereof shown in FIG. 3A;

FIG. 4 is a schematic block configuration diagram of the sensor;

FIG. 5 is an enlarged view of an opening of the sensor as viewed from in front of the opening;

FIG. 6 is a schematic cross-sectional view illustrating a first variation of the sensor;

FIG. 7 is a schematic cross-sectional view illustrating a second variation of the sensor;

FIG. 8A is a perspective view illustrating a third variation of the sensor as viewed from below the sensor;

FIG. 8B is a plan view illustrating the third variation of the sensor, of which some constituent elements are seen through in phantom lines;

FIG. 9A is a perspective view illustrating a fourth variation of the sensor as viewed from below the sensor;

FIG. 9B is a plan view illustrating the fourth variation of the sensor, of which some constituent elements are seen through in phantom lines;

FIG. 10A is a perspective view illustrating a fifth variation of the sensor as viewed from below the sensor;

FIG. 10B is a plan view illustrating the fifth variation of the sensor, of which some constituent elements are seen through in phantom lines;

FIG. 11 is a perspective view illustrating another variation of the sensor as viewed from below the sensor;

FIG. 12A is a side view illustrating a principal part of a sensor according to a second embodiment;

FIG. 12B is a cross-sectional view illustrating the principal part of the sensor as taken along a horizontal plane;

FIG. 13A is a side view illustrating a principal part of a first variation of the sensor;

FIG. 13B is a cross-sectional view illustrating the principal part of the first variation as taken along a horizontal plane;

FIG. 13C is a cross-sectional view illustrating a principal part of a modified example of the first variation as taken along a horizontal plane;

FIG. 14A is a side view illustrating a principal part of a second variation of the sensor;

FIG. 14B is a cross-sectional view illustrating the principal part of the second variation as taken along a horizontal plane;

FIG. 14C is a perspective view illustrating the principal part of the second variation;

FIG. 15 is an exploded perspective view illustrating the principal part of the second variation;

FIG. 16 is a side view illustrating a principal part of a third variation of the sensor;

FIG. 17A is a side view illustrating a principal part of a fourth variation of the sensor;

FIG. 17B is a cross-sectional view illustrating the principal part of the fourth variation as taken along a horizontal plane;

FIG. 18A is a perspective view of a sensor according to a third embodiment as viewed from below the sensor;

FIG. 18B is a plan view of the sensor, of which some constituent elements are seen through in phantom lines;

FIG. 18C is a cross-sectional view illustrating a principal part, located around an inlet port, of the sensor as taken along a vertical plane;

FIG. 19A illustrates how to conduct, using a tester, a heating test on the sensor installed on a structural component;

FIG. 19B is a schematic cross-sectional view of the tester in a state where the sensor is covered with the tester;

FIG. 20 is a perspective view illustrating a variation of the sensor as viewed from below the sensor;

FIG. 21A is a perspective view illustrating how the body of a sensor according to a fourth embodiment is installed directly onto a structural component using a mounting base;

FIG. 21B is an exploded perspective view illustrating the body of the sensor and the mounting base;

FIG. 22A is a perspective view illustrating how the body of the sensor is installed to be embedded into a structural component using an embedded base;

FIG. 22B is an exploded perspective view illustrating the body of the sensor and the embedded base;

FIG. 23A is a partial cross-sectional view schematically illustrating how the embedded base is mounted onto a structural component using first mounting brackets; and

FIG. 23B is a partial cross-sectional view schematically illustrating how the embedded base is mounted onto the structural component using second mounting brackets.

## Description of Embodiments

### [0008] (First embodiment)

#### (1) Overview

[0009] The drawings to be referred to in the following description of embodiments 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.

[0010] A sensor 1 according to an exemplary embodiment may be implemented as, for example, a fire sensor, which includes a heat sensitive element 30 for detecting heat generated by a fire, for example. In other words, the sensor 1 has at least the capability of detecting heat. In the following description, the sensor 1 is supposed to be a so-called "combination fire sensor" (see FIGS. 1-5) in which the sensor 1 further includes a smoke detection unit 4 (see FIG. 1). Optionally, the sensor 1 may include, instead of, or in addition to, the smoke detection unit 4, a detection unit for detecting, for example, the presence of a flame, gas leakage, or carbon monoxide (CO) pro-

duced by imperfect combustion.

[0011] As shown in FIG. 2, the sensor 1 is installed on a structural component X1 (e.g., a ceiling in the example illustrated in FIG. 2), which is a building component such as the ceiling or a wall of a building, for example.

[0012] As shown in FIGS. 1-3A, the sensor 1 includes a board 2, a single or a plurality of heat sensitive elements 30, and a housing 5. In this embodiment, the sensor 1 includes four heat sensitive elements 30 as an example.

[0013] The housing 5 houses the board 2 therein. As shown in FIG. 1, the housing 5 has: a flow channel 6 provided in an internal space SP1 thereof and allowing a gas to flow therethrough; and an opening 7 connecting the flow channel 6 to an external space SP2 outside of the housing 5. In FIG. 1, the flow channel 6 is indicated schematically by dotted arrows to make the gas flow easily understandable. Actually, however, the gap surrounding the smoke detection unit 4 in the internal space SP1 generally corresponds to the flow channel 6. Also, in this embodiment, the housing 5 has six openings 7 (only two of which are shown in FIG. 2) as an example.

[0014] In this embodiment, the heat sensitive elements 30 may be implemented as chip thermistors, each of which is mounted on the board 2 as shown in FIG. 1 to detect the heat of the gas that has flowed in through the openings 7.

[0015] According to this configuration, the heat sensitive elements 30 are implemented as chip thermistors mounted on the board 2, thus contributing to reducing the overall size (e.g., the thickness, among other things) of the sensor 1, compared to Patent Literature 1 in which the heat sensitive element is provided at the upper end of a lead wire.

35 (2) Details

#### (2.1) Overall configuration

[0016] Next, an overall configuration of the sensor 1 according to this embodiment will be described in detail. The sensor 1 is implemented as a so-called "combination fire sensor" for detecting both heat and smoke as described above.

[0017] In the following description, the sensor 1 is supposed to be installed on a ceiling surface (which is one surface of the structural component X1) as in the example illustrated in FIG. 2. Thus, in the following description, the upward/downward directions, rightward/leftward directions, and forward/backward directions will be defined with respect to the sensor 1 based on the upward, downward, rightward, leftward, forward, and backward arrows shown in FIG. 2. Note that these arrows are just shown there as an assistant to description and are insubstantial ones. It should also be noted that these directions do not define the directions in which the sensor 1 according to this embodiment should be used.

[0018] The sensor 1 includes a heat detection unit 3 including the four heat sensitive elements 30 described

above. The sensor 1 includes not only the board 2, the heat detection unit 3, the smoke detection unit 4, and the housing 5 but also a display unit 8 and a control unit 9 (see FIG. 4) as well. In addition, the sensor 1 further includes a mounting member 10 for mounting the sensor 1 onto the structural component X1 (see FIG. 1). Note that a mounting structure (such as a disklike mounting base) to be provided on the structural component X1, to which the mounting member 10 is fixed, is not illustrated in FIG. 1. The sensor 1 is mounted removably onto the mounting base fixed on the structural component X1.

**[0019]** The sensor 1 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 (not shown) or any other device, and receiving a signal from the alarm device, for example.

**[0020]** 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

**[0021]** The housing 5 houses the board 2, the heat detection unit 3, the smoke detection unit 4, a light source 81 of the display unit 8, the control unit 9, the communications unit 11, and other circuit modules therein. In addition, the housing 5 also supports the display unit 8 such that one surface of a guide portion 82 of the display unit 8 is exposed to the external space (see FIG. 2).

**[0022]** The housing 5 is made of a synthetic resin and may be made of flame-retardant ABS 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 FIG. 1, the housing 5 includes: a circular cylindrical front cover 51, of which one surface (e.g., an upper surface in the example illustrated in FIG. 1) is open; and a disklike back cover 52. The housing 5 has an installation surface 55 (see FIG. 1) to face the structural component X1 on which the sensor 1 is to be mounted. In this embodiment, one surface (i.e., the upper surface) of the back cover 52 corresponds to the installation surface 55. The housing 5 is formed by attaching the back cover 52 into the front cover 51 such that the back cover 52 is inserted through the opened surface of the front cover 51.

**[0023]** As described above, the housing 5 has the flow channel 6 provided in the internal space SP1 thereof and allowing a gas to flow therethrough, and six side inlets (lateral ports) 7A serving as six openings 7 connecting the flow channel 6 to the external space SP2. In other words, the openings 7 include the side inlets 7A. The number of the openings 7 provided is not limited to any particular number. Considering that the gas needs to be introduced into, and exhausted out of, the housing 5 smoothly, two or more openings 7 are suitably provided.

**[0024]** In this embodiment, six openings 7 (six side inlets 7A) are provided through the front cover 51. Specifically, as shown in FIGS. 1 and 2, the front cover 51 in-

cludes: a compressed circular cylindrical body 510, of which the upper and lower ends are opened; a disklike base portion 511 provided under the circular cylindrical body 510; and a plurality of (e.g., six) beams 512 that connect the circular cylindrical body 510 to the base portion 511. The circular cylindrical body 510, the base portion 511, and the six beams 512 are formed integrally with each other. The six beams 512 are arranged at nearly regular intervals along the circumference of the peripheral edge portion of the base portion 511 and protrude from the peripheral edge portion toward the opened lower edge portion of the circular cylindrical body 510. These six beams 512 are provided to keep a predetermined distance between the circular cylindrical body 510 and the base portion 511. The six openings 7 are provided through the peripheral wall of the front cover 51 with such a configuration and arranged at nearly regular intervals along the circumference of the peripheral wall.

**[0025]** Each of these openings 7 (each of these side inlets 7A) is a generally rectangular through hole, which radially penetrates through the peripheral wall of the front cover 51 and serves as a hole connecting the flow channel 6 to the external space SP2.

**[0026]** The front cover 51 includes, on the upper surface of the base portion 511, a positioning structure for positioning the board 2. An exemplary positioning structure may be formed by providing a positioning recess on the upper surface of the base portion 511 and fitting a hook piece, protruding from the board 2, into the recess. As shown in FIG. 3A, the base portion 511 has a diameter, which is somewhat larger than the diameter of the board 2 as shown in FIG. 3A.

**[0027]** In addition, the base portion 511 of the front cover 51 further has a pair of ports 513 (see FIG. 3A), through each of which one surface (i.e., lower surface) of the guide portion 82 of the display unit 8 is exposed to the external space SP2.

**[0028]** When the base portion 511 is viewed from under the base portion 511, the pair of ports 513 are located close to the peripheral edge portion of the base portion 511. The pair of ports 513 are arranged at regular intervals along the circumference of the base portion 511. In other words, the pair of ports 513 are arranged such that a virtual line connecting these two ports 513 together substantially generally passes through the center of the base portion 511. The direction in which the pair of ports 513 are arranged corresponds to the forward/backward direction according to the present disclosure.

**[0029]** Each port 513 penetrates through the base portion 511 along the thickness thereof (i.e., in the upward/downward direction). Each port 513 has a generally rectangular opening. An associated guide portion 82 is fitted into each port 513. This allows the light emitted from the pair of light sources 81 to be guided out of the housing 5 through the pair of guide portions 82.

**[0030]** The back cover 52 has a plurality of fitting holes 520 (see FIG. 1), into which fitted are a plurality of (e.g., four) connection pieces 101 of the mounting member 10

that is fixed on the board 2. The plurality of connection pieces 101 are electrically connected to a circuit module provided on the board 2. The plurality of connection pieces 101 are inserted to the point that their respective tips protrude sufficiently from the back surface of the back cover 52 (i.e., from the installation surface 55 thereof). The plurality of connection pieces 101 may be mechanically and electrically connected to contact portions of a mounting base (not shown) fixed onto the structural component X1. That is to say, the mounting member 10 is used to not only mechanically connect this sensor 1 to the mounting base but also electrically connect the sensor 1 to electric cables (including power cables and signal cables) provided on the back of the structural component X1 and position the board 2 with good stability with respect to the back cover 52. As used herein, "positioning" includes positioning the board 2 not only in the radial direction but also in the upward/downward directions as well.

**[0031]** In addition, the back cover 52 further has a housing recess 521, which is provided on one surface thereof facing the board 2 (i.e., the lower surface) to house an upper part of the smoke detection unit 4 mounted on the board 2 (see FIG. 1). That is to say, the housing recess 521 allows the smoke detection unit 4 to be positioned with good stability.

**[0032]** Furthermore, the back cover 52 further includes, on one surface thereof facing the board 2 (i.e., the lower surface thereof), a plurality of (e.g., four in the example illustrated in FIG. 3A) control plates (wall members) 522 (see FIG. 3A) for controlling the flow of a gas along the flow channel 6. Each control plate 522 is formed in a generally arc shape as viewed from the board 2. Each control plate 522 protrudes in a direction pointing toward the base portion 511 of the front cover 51 (i.e., in the downward direction). The four control plates 522 are arranged, in the vicinity of the peripheral edge portion of the back cover 52, at nearly regular intervals along the circumference of the back cover 52 as viewed from the board 2. The four control plates 522 each control (guide) the gas flow to allow the gas flowing along the flow channel 6 to be more easily directed toward either the heat sensitive elements 30 or the smoke detection unit 4 in the internal space SP1 of the housing 5. The number of the control plates 522 provided is not limited to any particular number. Optionally, only one control plate 522 may be provided.

### (2.3) Board

**[0033]** The board 2 is implemented as a printed wiring board. On the board 2, mounted are, for example, the heat detection unit 3, the smoke detection unit 4, the display unit 8, the control unit 9, the communications unit 11, and other circuit modules (not shown). Examples of the other circuit modules include a lighting circuit for turning ON the light sources 81 of the display unit 8 and the optical element 41 of the smoke detection unit 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.

**[0034]** As shown in FIG. 3A, the board 2 is formed in a generally circular shape as a whole. FIG. 3A is a plan view of the sensor 1, of which some constituent elements (namely, the board 2, the control plates 522, and the smoke detection unit 4) are seen through in phantom lines, as viewed from under the sensor 1.

**[0035]** In this embodiment, at least the four heat sensitive elements 30 of the smoke detection unit 4 are surface-mounted on a first surface 21 (i.e., a surface) of the board 2. The first surface 21 is the upper surface (see FIG. 1). In this embodiment, the smoke detection unit 4 is also arranged on the same plane as the first surface 21 of the board 2. The smoke detection unit 4 is mounted on the first surface 21 of the board 2. A labyrinth structure 43 (to be described later) of the smoke detection unit 4 includes, on the lower surface of a bottom portion thereof, engaging hooks, which are brought into engagement with engageable holes provided through the board 2, to be fixed onto the board 2. In addition, the light sources 81 of the display unit 8 are also mounted on the first surface 21 of the board 2.

**[0036]** The control unit 9 and a plurality of electronic components that form the circuit modules are mounted on either the first surface 21 or second surface 22 of the board 2. The control unit 9 and the plurality of electronic components that form the circuit modules do not have to be mounted on only the board 2. Optionally, an additional mount board may be arranged around the board 2 and some or all of the control unit 9 and those electronic components may be mounted on the additional mount board.

**[0037]** In the following description, the other surface, opposite from the first surface 21 (upper surface), of the board 2 will be hereinafter sometimes referred to as a "second surface (lower surface) 22." In FIG. 3A, the board 2 is illustrated as a see-through one and the second surface 22 thereof is seen. The heat sensitive elements 30, the light sources 81, and the smoke detection unit 4 are actually mounted on the first surface 21 that is opposite from the second surface 22 but are illustrated in FIG. 3A as being seen through, for the sake of convenience of description. In particular, in FIG. 3A, the optical element 41 and photosensitive element 42, which are arranged inside the labyrinth structure 43 of the smoke detection unit 4, are illustrated in the simplified form of dots.

**[0038]** Of the first surface 21 and the second surface 22, the first surface 21 corresponds to a surface located closer to the installation surface 55. Thus, it can be said that the heat sensitive elements 30 and the smoke detection unit 4 are all arranged on the surface, located closer to the installation surface 55, of the board 2.

**[0039]** Next, the structure of the board 2 will be described in detail. As shown in FIG. 3A, the board 2 includes: a circular body 200; and a plurality of (e.g., eight in the example illustrated in FIG. 3A) extended portions which are extended away from the center of the body

200. In the following description, these eight extended portions will be hereinafter referred to as a pair of first extended portions 201, a pair of second extended portions 202, a pair of third extended portions 203, and a pair of fourth extended portions 204.

**[0040]** The smoke detection unit 4 is arranged on the upper surface of the body 200. Meanwhile, the four heat sensitive elements 30 and the two light sources 81 are respectively arranged on the six extended portions (201, 202, 203).

**[0041]** The pair of first extended portions 201 are respectively extended in mutually opposite directions from the right and left edges of the body 200. On the upper surface of each first extended portion 201, placed is an associated single connection piece 101. Each first extended portion 201 further has, at the tip thereof, a small piece Y1 with a narrower width. On the upper surface of each small piece Y1, placed is an associated single heat sensitive element 30.

**[0042]** The pair of second extended portions 202 are respectively extended in mutually opposite directions from the front and rear edges of the body 200. The second extended portions 202 are extended to a shorter length than any other extended portion. On the upper surface of each second extended portion 202, placed is an associated single light source 81.

**[0043]** The pair of third extended portions 203 are respectively extended in mutually opposite directions from respective points, which are slightly shifted counterclockwise from the front and rear edges of the body 200 when viewed from under the board 2. Specifically, the front third extended portion 203 is arranged on the left of the front second extended portion 202, and the rear third extended portion 203 is arranged on the right of the rear second extended portion 202. Each third extended portion 203, as well as the first extended portions 201, has, at the tip thereof, a small piece Y1 with a narrower width. On the upper surface of each small piece Y1, placed is an associated single heat sensitive element 30.

**[0044]** The pair of fourth extended portions 204 are respectively extended in mutually opposite directions from respective points, which are slightly shifted clockwise from the front and rear edges of the body 200 when viewed from under the board 2. Specifically, the front fourth extended portion 204 is arranged on the right of the front second extended portion 202, and the rear fourth extended portion 204 is arranged on the left of the rear second extended portion 202. On the upper surface of each fourth extended portion 204, placed is an associated single connection piece 101.

**[0045]** That is to say, the board 2 may have, for example, a dyad symmetric shape, which makes the board 2 symmetric when the board 2 is rotated 180 degrees around its center.

**[0046]** Each of the pair of first extended portions 201 and the pair of third extended portions 203, on which the four heat sensitive elements 30 are respectively arranged, has a through hole 31 (see FIG. 3B), which has

a rectangular opening. FIG. 3B is an enlarged view of the part indicated by the dotted circle (in phantom lines) in FIG. 3A. The through hole 31 is located inside of the heat sensitive element 30 (i.e., closer to the center of the internal space SP1). The heat sensitive element 30 and the through hole 31 are arranged adjacent to each other. Providing such a through hole 31 beside each heat sensitive element 30 allows the area of the board 2 to be reduced around the heat sensitive element 30, thus reducing the chances of the temperature of the heat being lowered by being transferred through the board 2. That is to say, the through hole 31 improves the thermal insulation properties. The aperture area of the through hole 31 is suitably larger than the surface area of the heat sensitive element 30 (e.g., the surface area as viewed from over the board 2).

#### (2.4) Heat detection unit and smoke detection unit

**[0047]** As described above, the heat detection unit 3 includes the four heat sensitive elements 30 which are mounted on the first surface 21 of the board 2 (and only one of which is shown in FIG. 4). 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 according to this embodiment is implemented as a chip thermistor for detecting the heat of a gas that has flowed in through the opening 7 and is surface-mounted on the board 2. The respective heat sensitive elements 30 are arranged such that each of the heat sensitive elements 30 faces an associated one of the four different openings 7. Note that the relative positions of the heat sensitive elements 30 with respect to the flow channel 6 and the openings 7 will be described in detail later in the "(2.7) Arrangement structure of heat detection unit" section.

**[0048]** The heat detection unit 3 is electrically connected, via patterned wiring formed on the board 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.

**[0049]** 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.

**[0050]** The smoke detection unit 4 is arranged in a central area of the internal space SP1 and configured to detect smoke. Specifically, the smoke detection unit 4 is arranged on the upper surface of the body 200 of the

board 2 and has an upper part thereof housed in the housing recess 521 of the back cover 52. The smoke detection unit 4 may be implemented as a photoelectric sensor for detecting smoke, for example. As shown in FIG. 4, the smoke detection unit 4 includes an optical element 41 for emitting light, a photosensitive element 42 for receiving the light emitted from the optical element 41, and a labyrinth structure 43. The optical element 41 may be implemented as a light-emitting diode (LED), for example. The photosensitive element 42 may be implemented as a photodiode, for example. The labyrinth structure 43 is formed inside a case having a compressed, generally circular cylindrical shell. The case of the smoke detection unit 4 has a structure having, on an outer peripheral surface thereof, a plurality of ports to introduce a gas into the labyrinth structure 43 and reducing incidence of external light onto the internal space thereof.

**[0051]** The optical element 41 and the photosensitive element 42 are arranged in the labyrinth structure 43 to avoid facing each other. In other words, the optical element 41 and the photosensitive element 42 are arranged such that the photosensitive plane of the photosensitive element 42 is off the optical axis C1 (see FIG. 3A) of the light emitted from the optical element 41.

**[0052]** At the outbreak of a fire, for example, smoke may enter the housing 5 through the openings 7 of the housing 5 and be introduced into the labyrinth structure 43. If no smoke is present in the labyrinth structure 43, the light emitted from the optical element 41 hardly reaches the photosensitive plane of the photosensitive element 42. On the other hand, if there is any smoke in the labyrinth structure 43, then the light emitted from the optical element 41 is scattered by the smoke and part of the scattered light eventually impinges on the photosensitive plane of the photosensitive element 42. That is to say, the smoke detection unit 4 is configured to have the light, which has been emitted from the optical element 41 and scattered by the smoke, received at the photosensitive element 42.

**[0053]** The photosensitive element 42 of the smoke detection unit 4 is electrically connected to the control unit 9. The smoke detection unit 4 transmits an electrical signal (detection signal), having a voltage level corresponding to the quantity of light received at the photosensitive element 42, 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 unit 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 unit 4 may convert the quantity of light received at the photosensitive element 42 into a smoke concentration and then transmit a detection signal, having a voltage level corresponding to the smoke concentration, to the control unit 9.

**[0054]** The smoke detection unit 4 may further include

an amplifier circuit for amplifying the electrical signal provided by the photosensitive element 42, 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 41 for use to detect smoke does not have to be one but may also be plural.

## (2.5) Display unit

**[0055]** The display unit 8 includes a pair of light sources 81 and a pair of guide portions 82. Each of the light sources 81 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 81 is mounted on the board 2 as described above. Each guide portion 82 is a portion formed in a generally L shape and having a light-transmitting property. Each guide portion 82 has an incident surface which faces an associated light source 81 on the board 2 and on which the light emitted from the light source 81 is incident. Each guide portion 82 also has an emergent surface, through which the light incident from the incident surface emerges out of the guide portion 82. The emergent surface of each guide portion 82 is exposed through an associated port 513 of the front cover 51.

**[0056]** The display unit 8 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 81 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 81 under the control of the control unit 9. Note that in FIG. 4, illustration of the lighting circuit between the control unit 9 and the display unit 8 is omitted.

## (2.6) Control unit

**[0057]** The control unit 9 is implemented as a microcontroller including, as major constituent elements, a central processing unit (CPU) and a memory. That is to say, the control unit 9 is implemented as a computer including the CPU and the memory. The computer performs the function of the control unit 9 by making the CPU execute a program stored in the memory. In this embodiment, the program is stored in advance in the memory. 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.

**[0058]** The control unit 9 is configured to control the communications unit 11 and circuit modules (including the lighting circuit and the power supply circuit).

**[0059]** In addition, the control unit 9 is also configured to receive detection signals from the heat detection unit 3 and the smoke detection unit 4 to determine whether or not a fire is actually present. Specifically, the control unit 9 monitors the respective detection signals provided by the four 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 unit 4 and decides, on finding the signal level (corresponding to the quantity of light received at the photosensitive element 42 or a smoke concentration) included in the detection signal greater than a threshold value, that a fire should be present.

**[0060]** 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 101 of the mounting member 10, the connector portion of the mounting base, and the signal cables provided on the back of the structural component X1. 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 81 of the display unit 8 (indicating lamp).

#### (2.7) Arrangement structure of heat detection unit

**[0061]** Next, the arrangement structure of the heat detection unit 3 according to this embodiment will be described.

**[0062]** In this embodiment, each heat sensitive element 30 of the heat detection unit 3 is implemented as a chip thermistor mounted on the first surface 21 of the board 2 as described above, thus contributing to reducing the overall size (the thickness, among other things) of the sensor 1. In addition, this also cuts down the cost of the thermistor itself and the mounting cost thereof, compared to lead-type thermistors.

**[0063]** Furthermore, in this embodiment, at least part of the first surface 21 (surface) of the board 2 is exposed to the flow channel 6. In this case, the smoke detection unit 4 is arranged in the central area of the first surface 21, and a central region of the internal space SP1 of the housing 5 is mostly occupied by the smoke detection unit 4. The flow channel 6 substantially corresponds to a space surrounding the central region (smoke detection unit 4) of the internal space SP1. In other words, the flow

channel 6 has a generally doughnut shape. Thus, in this embodiment, a peripheral area, other than the area on which the smoke detection unit 4 is mounted, of the entire area of the first surface 21 of the board 2 is exposed to the flow channel 6. The peripheral area includes the respective upper surfaces of the eight extended portions (201-204) in total.

**[0064]** Exposing the peripheral area of the first surface 21 of the board 2 to the flow channel 6 in this manner further increases the chances of the four heat sensitive elements 30, provided for the first extended portions 201 and the third extended portions 203, being exposed to the gas flowing through the flow channel 6, even though the heat sensitive elements 30 are implemented as chip thermistors.

**[0065]** Specifically, while a gas having heat generated by the outbreak of a fire, for example, is rising from under the sensor 1, the gas is introduced through the plurality of openings 7 into the housing 5 to flow along the flow channel 6. In the meantime, the heat sensitive elements 30 detect the heat, of which the temperature is high enough to indicate the presence of a fire, thus allowing the sensor 1 to quickly decide that a fire should be present. This contributes to downsizing the sensor 1 while further improving the heat detection performance of the sensor 1.

**[0066]** In this case, the sensor 1 according to this embodiment further includes the smoke detection unit 4. The smoke detection unit 4 is located in the central area of the internal space SP1 at the depth of the flow channel 6. In other words, the flow channel 6 is a channel that allows both heat and smoke to pass through in common. Thus, if the gas introduced into the housing 5 through the plurality of openings 7 has a smoke concentration equal to or greater than a predetermined concentration, the sensor 1 is also able to detect smoke. This contributes to reducing the overall size of the sensor 1 while further improving the fire sensing performance thereof.

**[0067]** Furthermore, in this embodiment, the respective heat sensitive elements 30 implemented as chip thermistors are arranged such that each heat sensitive element 30 faces a different one of the openings 7 from any other one of the heat sensitive elements 30. In the example illustrated in FIG. 1, the heat sensitive element 30 on the left is arranged to face a single opening 7 on the left, and the heat sensitive element 30 on the right is arranged to face another opening 7 on the right. In addition, each heat sensitive element 30 is arranged, when the open area 70 of an associated opening 7 (see FIGS. 1 and 5) is viewed from the external space SP2, to fall within the generally rectangular open area 70. In other words, when viewed along a normal to the circular cylindrical body 510 of the housing 5, each heat sensitive element 30 is arranged to fall within the open area 70. That is to say, a part, projected onto the open area 70, of each heat sensitive element 30 falls within the open area 70. This increases the chances of the heat sensitive element 30 being exposed to the gas that has flowed in

through the opening 7, compared to a situation where at least part of the heat sensitive element 30 is arranged outside of the open area 70, i.e., behind the circular cylindrical body 510 of the housing 5 or behind the beams 512.

**[0068]** In particular, in this embodiment, when the open area 70 is viewed from the external space SP2, each heat sensitive element 30 implemented as a chip thermistor is located, inside the open area 70, at the middle of the open area 70 in a direction perpendicular to the first surface 21 (i.e., in the upward/downward direction) as shown in FIG. 5. In other words, the relative positions of the openings 7 and the board 2 are defined such that each heat sensitive element 30 is located at the middle of the open area 70. This positional relationship may be adjusted by changing the protrusion height of the ribs 514 (see FIG. 1) protruding from the back surface of the base portion 511 of the front cover 51 to contact with the board 2 and the insertion depth of the connection pieces 101 of the mounting member 10, for example. Adopting such a positional relationship increases, compared to a situation where the heat sensitive element 30 is located close to one end of the open area 70 (i.e., close to either the upper end or the lower end), for example, the chances of the heat sensitive element 30 being exposed to the gas flowing in through the opening 7.

**[0069]** In addition, in this embodiment, each heat sensitive element 30 is arranged not only beside the smoke detection unit 4 but also in the vicinity of an associated one of the openings 7. In other words, if the flow channel 6 is divided into a first channel 61 located closer the opening 7 and a second channel 62 connected to the first channel 61 and located closer to a central area of the internal space SP1, each heat sensitive element 30 implemented as a chip thermistor is provided in the first channel 61 (see FIG. 1). The increases, compared to a situation where the chip thermistor is provided in the second channel 62, for example, responsivity to heat detection. Note that in FIG. 1, the flow channel 6 is indicated schematically by the dotted arrows as described above. Actually, however, the first channel 61 corresponds to the outer half of the air gap surrounding the smoke detection unit 4 in the internal space SP1, and the second channel 62 corresponds to the inner half of the air gap.

**[0070]** Meanwhile, when measured along the thickness of the board 2 (i.e., in the upward/downward direction), the middle P1 of the internal space of the labyrinth structure 43 is suitably located between the heat sensitive elements 30 implemented as the chip thermistors and the installation surface 55 (see FIG. 1). In other words, the heat sensitive elements 30 are located below the middle PI in the upward/downward direction. In FIG. 3A, the optical element 41 and photosensitive element 42 arranged in the labyrinth structure 43 are schematically indicated by dots. In this embodiment, the optical element 41 and the photosensitive element 42 may have the same height and the intersection between the optical axis C1 of the optical element 41 and the optical axis C2

of the photosensitive element 42 may substantially agree with the middle PI, for example.

**[0071]** The height levels of the optical element 41 and the photosensitive element 42 and the directions of their optical axes C1 and C2 are not limited to any particular ones, as long as the optical axis C1 does not intersect with the photosensitive plane of the photosensitive element 42. For example, the height of one of the optical element 41 or the photosensitive element 42 may be lower than that of the other. In addition, the optical axes C1 and C2 do not have to intersect with each other. In that case, as viewed from beside the smoke detection unit 4, a midpoint between the optical axes C1 and C2 may substantially agree with the middle PI.

**[0072]** Setting the middle PI between the heat sensitive elements 30 and the installation surface 55 in this manner allows the smoke (the gas) that has passed through the heat sensitive elements 30 to be effectively guided toward the smoke detection unit 4, even though a gas with heat flowing through the flow channel 6 in the housing 5 tends to form a rising gas flow. This contributes to further reducing the overall size of the sensor 1 designed to detect not only heat but also smoke while further improving the fire sensing performance thereof.

### (3) Variations

**[0073]** 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. The functions of the sensor 1 according to the exemplary embodiment described above may also be implemented as, for example, a method for controlling the sensor 1, a computer program, or a non-transitory storage medium that stores the computer program.

**[0074]** 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."

**[0075]** The control unit 9 of the sensor 1 according to the present disclosure includes a computer system. In that case, the computer system may include, as principal hardware components, a processor and a memory. The functions of the control unit 9 of the sensor 1 according to the present disclosure may be performed by making the processor execute a program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been recorded in some non-transitory storage medium such as a memory card, an optical disc, or a hard disk

drive, any of which is readable for the computer system. The processor of the computer system may be made up of a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integrated circuit (LSI). As used herein, the "integrated circuit" such as an IC or an LSI is called by a different name depending on the degree of integration thereof. Examples of the integrated circuits include a system LSI, a very large-scale integrated circuit (VLSI), and an ultra-large scale integrated circuit (ULSI). Optionally, a field-programmable gate array (FPGA) to be programmed after an LSI has been fabricated or a reconfigurable logic device allowing the connections or circuit sections inside of an LSI to be reconfigured may also be adopted as the processor. Those electronic circuits may be either integrated together on a single chip or distributed on multiple chips, whichever is appropriate. Those multiple chips may be integrated together in a single device or distributed in multiple devices without limitation. As used herein, the "computer system" includes a microcontroller including one or more processors and one or more memories. Thus, the microcontroller may also be implemented as a single or a plurality of electronic circuits including a semiconductor integrated circuit or a large-scale integrated circuit.

**[0076]** Also, in the embodiment described above, the plurality of constituent elements (or the functions) of the control unit 9 of the sensor 1 are integrated together in a single housing. However, this is not an essential configuration for the sensor 1. Alternatively, those constituent elements (or functions) of the sensor 1 may be distributed in multiple different housings. Still alternatively, at least some functions of the sensor 1 (e.g., some functions of the sensor 1) may be implemented as a cloud computing system as well. Conversely, the plurality of functions of the sensor 1 may be integrated together in a single housing as in the basic example described above.

(3.1) First variation

**[0077]** Next, a sensor 1A according to this variation (first variation) will be described with reference to FIG. 6. In the following description, any constituent element of the sensor 1A, having substantially the same function as a counterpart of the sensor 1 according to the basic example described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. FIG. 6 is a schematic cross-sectional view of the sensor 1A.

**[0078]** The sensor 1A includes a gas flow regulating member Z1 in the internal space SP1, which is a major difference from the basic example described above. The gas flow regulating member Z1 is extended from a lower edge of the circular cylindrical body 510 of the front cover 51 of the housing 5 toward the smoke detection unit 4. The gas flow regulating member Z1 is a plate member

having a generally doughnut shape when viewed in the upward/downward direction. The gas flow regulating member Z1 may be formed integrally with the front cover 51. Alternatively, the gas flow regulating member Z1 may be provided separately from the front cover 51 and fixed to the front cover 51 by screwing, for example.

**[0079]** The gas flow regulating member Z1 extends straight along the board 2 over a certain distance from the edge of each opening 7 toward the inside of the housing 5. Nevertheless, the gas flow regulating member Z1 starts being sloped on the way toward the installation surface 55 as the distance to the central region of the internal space SP1 decreases.

**[0080]** Thus, providing the gas flow regulating member Z1 for the sensor 1A makes the open cross-sectional area of the first channel 61 smaller than the open cross-sectional area of the second channel 62 when viewed along a line segment connecting one opening 7 to the central region of the internal space SP1. This allows the gas that has flowed in the flow channel 6 through the openings 7 to be accelerated to flow from the first channel 61 with the narrower space toward the second channel 62 with the broader space.

**[0081]** In particular, the gas flow regulating member Z1 starts being sloped on the way toward the installation surface 55, thus making the second channel 62 broader and broader in the direction pointing toward the installation surface 55 as the distance, measured in the direction from the first channel 61 toward the central region, to the central region decreases. This allows the smoke (the gas) that has passed through the heat sensitive elements 30 to be effectively guided toward the smoke detection unit 4, even though a gas with heat flowing through the flow channel 6 in the housing 5 tends to form a rising gas flow.

(3.2) Second variation

**[0082]** Next, a sensor 1B according to this variation (second variation) will be described with reference to FIG. 7. In the following description, any constituent element of the sensor 1B, having substantially the same function as a counterpart of the sensor 1 according to the basic example described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. FIG. 7 is a schematic cross-sectional view of the sensor 1B.

**[0083]** In the sensor 1B, the smoke detection unit 4 is mounted on the second surface 22 of the board 2, not on the first surface 21 thereof, which is a major difference from the basic example described above. Note that the heat sensitive elements 30 are mounted on the first surface 21 as in the basic example described above.

**[0084]** In the housing 5 of this sensor 1B, the front cover 51 includes a housing recess 515 for housing the smoke detection unit 4, because the smoke detection unit 4 is mounted on the second surface 22 (lower surface). Spe-

cifically, the base portion 511 of the front cover 51 is formed such that a central region thereof is convex down. In the basic example described above, the back cover 52 includes the housing recess 521 for housing an upper part of the smoke detection unit 4 (see FIG. 1).

**[0085]** The base portion 511 has ports 5111, provided through a peripheral wall of the convex down part 5110, for introducing a gas (smoke) into the housing 5.

**[0086]** In addition, the flow channel 6 is configured to be divided, at the board 2, into an upper flow channel 6X and a lower flow channel 6Y. The gas with heat passing through the upper flow channel 6X will pass through the heat sensitive elements 30. Meanwhile, part of the gas passing through the lower flow channel 6Y passes through the through holes 31 (see FIG. 3B) of the board 2 to rise toward the upper flow channel 6 and then pass through the heat sensitive elements 30. Meanwhile, the rest of the gas passing through the lower flow channel 6Y flows as it is toward the smoke detection unit 4 in the central region.

### (3.3) Third variation

**[0087]** Next, a sensor 1C according to this variation (third variation) will be described with reference to FIGS. 8A and 8B. In the following description, any constituent element of the sensor 1C, having substantially the same function as a counterpart of the sensor 1 according to the basic example described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. FIG. 8A is a perspective view illustrating the sensor 1C as viewed from below the sensor 1C. FIG. 8B is a plan view of the sensor 1C, of which some constituent element (only the board 2) is seen through in phantom lines, as viewed from under the sensor 1C.

**[0088]** The sensor 1C is implemented as a P-type thermal sensor for transmitting a fire warning signal to an external device by so-called "proprietary-type (P-type)" communication method. The sensor 1C includes the heat detection unit 3 as in the basic example but does not include the smoke detection unit 4 unlike the basic example. That is to say, the sensor 1C determines, only by detecting heat, whether or not a fire is present.

**[0089]** In addition, the sensor 1C includes three heat sensitive elements 30, which is another difference from the basic example (in which four heat sensitive elements 30 are provided).

**[0090]** As shown in FIG. 8B, the board 2 of the sensor 1C has a generally diamond shape as viewed from under the sensor 1C. Two out of the three heat sensitive elements 30 are surface-mounted on the first surface 21 (upper surface) of the diamond-shaped board 2. These two heat sensitive elements 30 are arranged at respective positions on the first surface 21 (upper surface) to diagonally face each other in the rightward/leftward direction. Specifically, the board 2 has, at both edges of the portions where the diagonally facing heat sensitive

elements 30 are provided, a pair of protruding portions 23 protruding outward (while slightly tilting with respect to the rightward/leftward direction). On the upper surface of each protruding portion 23, placed is an associated heat sensitive element 30. The other heat sensitive element 30 is placed on the upper surface of the central area of the board 2.

**[0091]** Also, as in the basic example described above, a through hole 31 is provided in the vicinity of each heat sensitive element 30 to improve the thermal insulation properties. As for the heat sensitive element 30 provided in the central area of the board 2, two semicircular through holes 31 are arranged to interpose the heat sensitive element 30 between themselves.

**[0092]** Furthermore, the front cover 51 of the sensor 1C has one inlet port (vertical hole) 7B and two auxiliary ports (vertical holes) 56, all of which are provided through the base portion 511 thereof. The two auxiliary ports 56 are provided in the vicinity of the right and left edges of the base portion 511. The inlet port 7B is arranged in the central area of the base portion 511. Each of the inlet port 7B and the two auxiliary ports 56 penetrates through the base portion 511 of the front cover 51 along the thickness thereof. The two auxiliary ports 56 provided in the vicinity of the right and left edges of the base portion 511 each have a generally crescent opening, while the inlet port 7B provided in the central area of the base portion 511 has a generally circular opening. The pair of protruding portions 23 of the board 2 face, and are associated one to one with, the two auxiliary ports 56, while the central area of the board 2 faces the central inlet port 7B. Consequently, the protruding portions 23 and the central area of the board 2 are exposed through the two auxiliary ports 56 and the inlet port 7B, respectively, as shown in FIG. 8B. Thus, the gas rising with heat enters the housing 5 through the two auxiliary ports 56 and the inlet port 7B and then flows toward the first surface 21 (upper surface) through the through holes 31. This allows the heat sensitive elements 30 to be more easily exposed to not only the gas flowing in through the openings 7 (side inlets 7A; lateral ports) but also the gas flowing in through the two auxiliary ports 56 and the inlet port 7B as well.

**[0093]** This configuration also contributes to reducing the overall size (the thickness, among other things) of the sensor 1C while further improving the fire sensing performance.

### (3.4) Fourth variation

**[0094]** Next, a sensor 1D according to this variation (fourth variation) will be described with reference to FIGS. 9A and 9B. In the following description, any constituent element of the sensor 1D, having substantially the same function as a counterpart of the sensor 1 according to the basic example described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. FIG. 9A is a perspective view illustrating the sensor 1D

as viewed from below the sensor ID. FIG. 9B is a plan view of the sensor ID, of which some constituent element (only the board 2) is seen through in phantom lines, as viewed from under the sensor ID.

**[0095]** The sensor ID is implemented as an R-type thermal sensor for transmitting a fire warning signal to an external device by so-called "record-type (R-type)" communication method. The sensor 1D includes the heat detection unit 3 as in the basic example but does not include the smoke detection unit 4 unlike the basic example. That is to say, the sensor ID, as well as the sensor 1C according to the third variation, determines, only by detecting heat, whether or not a fire is present.

**[0096]** In addition, the sensor ID includes five heat sensitive elements 30, which is another difference from the basic example (in which four heat sensitive elements 30 are provided).

**[0097]** The board 2 of the sensor ID has a shape which is somewhat similar to that of the board 2 according to the basic example as shown in FIG. 9B. Specifically, the board 2 of the sensor ID includes: a circular body 200; and a plurality of (e.g., six in the example illustrated in FIG. 9B) extended portions extended away from the center of the body 200. In the following description, these six extended portions will be hereinafter referred to as a pair of first extended portions 201, a pair of second extended portions 202, and a pair of third extended portions 203. One of the five heat sensitive elements 30 is provided in the central area of the body 200, while the other four heat sensitive elements 30 and the two light sources 81 are respectively arranged in the six extended portions (201, 202, 203).

**[0098]** The pair of first extended portions 201 are respectively extended in mutually opposite directions from the right and left edges of the body 200. Each first extended portion 201 further has, at the tip thereof, a small piece Y1 with a narrower width. On the upper surface of each small piece Y1, placed is an associated single heat sensitive element 30.

**[0099]** The pair of second extended portions 202 are respectively extended in mutually opposite directions from the front and rear edges of the body 200. The second extended portions 202 are extended to a shorter length than any other extended portion. On the upper surface of each second extended portion 202, placed is an associated single light source 81.

**[0100]** The pair of third extended portions 203 are respectively extended in mutually opposite directions from respective points, which are slightly shifted counterclockwise from the front and rear edges of the body 200 when viewed from under the board 2. Specifically, the front third extended portion 203 is arranged on the left of the front second extended portion 202, and the rear third extended portion 203 is arranged on the right of the rear second extended portion 202. Each third extended portion 203, as well as the first extended portions 201, has, at the tip thereof, a small piece Y1 with a narrower width. On the upper surface of each small piece Y1, placed is

an associated single heat sensitive element 30.

**[0101]** That is to say, the board 2 of the sensor 1D may have, for example, a dyad symmetric shape, which makes the board 2 symmetric when the board 2 is rotated 180 degrees around its center.

**[0102]** In addition, as in the basic example, a through hole 31 is provided in the vicinity of each heat sensitive element 30 to improve the thermal insulation properties. As for the heat sensitive element 30 provided in the central area of the board 2, two semicircular through holes 31 are arranged to interpose the heat sensitive element 30 between themselves. Also, as in the basic example area, a pair of guide portions 82 of the display unit 8 are exposed through the front cover 51 of the sensor 1D.

**[0103]** The front cover 51 of the sensor ID has one inlet port (vertical hole) 7B and two auxiliary ports (vertical holes) 57, all of which are provided through the base portion 511 thereof. The two auxiliary ports 57 are provided in the vicinity of the right and left edges of the base portion 511. The inlet port 7B is provided in the central area of the base portion 511. Each of the two auxiliary ports 57 and the inlet port 7B penetrates through the base portion 511 of the front cover 51 along the thickness thereof. The two auxiliary ports 57 provided in the vicinity of the right and left edges of the base portion 511 each have a generally rectangular opening, while the inlet port 7B provided in the central area of the base portion 511 has a generally circular opening. The respective tips of the small pieces Y1 in the pair of first extended portions 201 of the board 2 face, and are associated one to one with, the two auxiliary ports 57 on the right and on the left, while the central area of the board 2 faces the central inlet port 7B. Consequently, the respective tips of the small pieces Y1 and the central area of the board 2 are exposed through the two auxiliary ports 57 and the inlet port 7B, respectively, as shown in FIG. 9B. Thus, the gas rising with heat enters the housing 5 through the two auxiliary ports 57 and the inlet port 7B and then flows toward the first surface 21 (upper surface) through the through holes 31. This allows the heat sensitive elements 30 to be more easily exposed to not only the gas flowing in through the openings 7 (side inlets 7A; lateral ports) but also the gas flowing in through the two auxiliary ports 5 and the inlet port 7B as well.

**[0104]** This configuration also contributes to reducing the overall size (the thickness, among other things) of the sensor ID while further improving the fire sensing performance.

### (3.5) Fifth variation

**[0105]** Next, a sensor 1E according to this variation (fifth variation) will be described with reference to FIGS. 10A and 10B. In the following description, any constituent element of the sensor 1E, having substantially the same function as a counterpart of the sensor 1 according to the basic example described above, will be designated by the same reference numeral as that counterpart's, and

description thereof will be omitted as appropriate herein. FIG. 10A is a perspective view illustrating the sensor 1E as viewed from below the sensor 1E. FIG. 10B is a plan view of the sensor 1E, of which some constituent element (only the board 2) is seen through in phantom lines, as viewed from under the sensor 1E.

**[0106]** The sensor 1E may be implemented as a fire alarm device for emitting a sound such as an alarm sound when detecting the presence of a fire, for example. The sensor 1E includes the heat detection unit 3 as in the basic example but does not include the smoke detection unit 4 unlike the basic example. That is to say, the sensor 1E, as well as the sensor 1C according to the third variation and the sensor 1D according to the fourth variation, determines, only by detecting heat, whether or not a fire is present.

**[0107]** In addition, the sensor 1E further includes a loudspeaker, an acoustic circuit, and other components for emitting the sound such as the alarm sound, which is another difference from the basic example. Furthermore, the sensor 1E may be implemented as, for example, a battery-driven fire alarm device. Thus, the sensor 1E includes a battery and a housing space for housing the battery, for example. In the sensor 1E, an operating unit U1 is exposed on the front surface of the front cover 51.

**[0108]** The operating unit U1 accepts a command entered externally. The operating unit U1 is configured to be pressed down upward by the user's press operation, for example. Also, the operating unit U1 is a circular disk member with light transmitting properties. The operating unit U1 is arranged to face an indicating lamp in the housing 5. Furthermore, the operating unit U1 is configured to, when subjected to the press operation, to press a push button switch provided in the housing 5. Thus, if the operating unit U1 is pressed while an alarm sound is being emitted, for example, the alarm sound stops being emitted. In addition, while the sensor 1E is activated or runs out of battery, for example, the operating unit U1 shines. Optionally, an operation test, for example, may be conducted by operating the operating unit U1.

**[0109]** In addition, the sensor 1E includes three heat sensitive elements 30, which is another difference from the basic example (in which four heat sensitive elements 30 are provided).

**[0110]** As shown in FIG. 10B, the board 2 of the sensor 1E has an inverted Y shape when viewed from under the sensor 1E. In the sensor 1E, the loudspeaker, the battery, the operating unit U1, and other members with a relatively large volume are either housed or supported in the housing 5. Thus, to avoid these members, the board 2 has such an inverted Y shape, which also contributes to saving space.

**[0111]** Specifically, the board 2 of the sensor 1E includes: a generally circular body 200, of which a left half is partially cut out; and plurality of (e.g., three in the example illustrated in FIG. 10B) extended portions, which are provided along the edge of the body 200 to be extended away from the center of the body 200. In the following description, these three extended portions will be

hereinafter referred to as "extended pieces 205." The three heat sensitive elements 30 are arranged on the three extended pieces 205, respectively.

**[0112]** The front extended piece 205, out of the three extended pieces 205, is extended from the front edge of the body 200 and an associated one of the heat sensitive elements 30 is arranged on the upper surface of its tip portion. The rear two extended pieces 205, out of the three extended pieces 205, are extended from respective points, which are slightly shifted from the rear edge of the body 200 to the right and to the left, respectively, and associated two of the heat sensitive elements 30 are arranged on the upper surface of their respective tip portions.

**[0113]** In addition, as in the basic example, a through hole 31 is provided inside, and in the vicinity of, each heat sensitive element 30 to improve the thermal insulation properties. That is to say, three through holes 31 are provided in total.

**[0114]** The front cover 51 of the sensor 1E has a single auxiliary port (vertical hole) 58, which is provided through the base portion 511 thereof. The auxiliary port 58 is provided in the vicinity of the front edge of the base portion 511. The auxiliary port 58 penetrates through the base portion 511 of the front cover 51 along the thickness thereof. The auxiliary port 58 has a generally rectangular opening. The tip of the front extended piece 205, out of the three extended pieces 205, faces the auxiliary port 58. Consequently, the tip of the front extended piece 205 is exposed through the auxiliary port 58 as shown in FIG. 10B. Thus, the gas rising with heat enters the housing 5 through the auxiliary port 58 and then flows toward the first surface 21 (upper surface) through the through holes 31. This allows the heat sensitive elements 30 to be more easily exposed to not only the gas flowing in through the openings 7 (side inlets 7A; lateral ports) but also the gas flowing in through the auxiliary port 58 as well.

**[0115]** This configuration also contributes to reducing the overall size (the thickness, among other things) of the sensor 1E while further improving the fire sensing performance.

### (3.6) Other variations

**[0116]** The sensor 1 according to the basic example (implemented as a combination fire sensor) has no vertical holes provided through the front cover 51 thereof unlike the third to fifth variations. However, this is only an example of the present disclosure and should not be construed as limiting. Alternatively, as in the third to fifth variations, the sensor 1 (implemented as a combination fire sensor) may also have a single or a plurality of auxiliary ports (vertical holes) 59 (e.g., two in the example illustrated in FIG. 11) provided through the front cover 51 thereof as shown in FIG. 11.

**[0117]** In the basic example, the heat sensitive elements 30 are mounted on the first surface 21 (upper surface) of the board 2. However, this is only an example of

the present disclosure and should not be construed as limiting. Alternatively, the heat sensitive elements 30 may also be mounted on the second surface 22 (lower surface) of the board 2. Still alternatively, some of the heat sensitive elements 30 may be mounted on the first surface 21, while the other heat sensitive elements 30 may be mounted on the second surface 22. Optionally, both the heat sensitive elements 30 and the smoke detection unit 4 may be mounted on the second surface 22 (lower surface) of the board 2.

**[0118]** The number of the through hole(s) 31 adjacent to a single heat sensitive element 30 is supposed to be one in the basic example but may also be two or more as described for the third and fourth variations. For example, a plurality of through holes 31 may be provided to surround a single heat sensitive element 30.

**[0119]** In the basic example, each heat sensitive element 30 is mounted on the first surface 21 of the board 2 and the through hole 31 is provided adjacent to the heat sensitive element 30. Even if the heat sensitive elements 30 are mounted on the second surface 22 of the board 2, however, the through hole 31 is suitably provided adjacent to each of the heat sensitive elements 30.

**[0120]** In the basic example, the board 2 is implemented as a single printed wiring board. However, this is only an example of the present disclosure and should not be construed as limiting. Alternatively, the board 2 may also be implemented separately as two or more printed wiring boards. Nevertheless, in that case, the two or more printed wiring boards are suitably arranged on the same plane.

**[0121]** In the basic example, the openings 7 are lateral ports provided through the peripheral wall of the housing 5. However, this is only an example of the present disclosure and should not be construed as limiting. Alternatively, the openings 7 according to the present disclosure do not have to be lateral ports but may also correspond to the inlet port (vertical hole) 7B and the auxiliary ports (vertical holes) 56-58 according to the third to fifth variations, and the auxiliary port (vertical hole) 59 described above.

(Second embodiment)

**[0122]** Next, a sensor IF according to a second embodiment will be described with reference to FIGS. 12A and 12B. The sensor IF according to this embodiment further includes a shielding member V1, which is a major difference from the sensor (1, 1A-1E) according to the first embodiment (including variations thereof). In the following description, any constituent element of this second embodiment, having substantially the same function as a counterpart of the first embodiment described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. Optionally, the shielding member V1 according to this embodiment is applicable as appropriate to the sensor (1, 1A-1E) according to the first

embodiment.

**[0123]** The sensor IF shown in FIGS. 12A and 12B, as well as the sensor 1C according to the third variation of the first embodiment (see FIGS. 8A and 8B), may be implemented as a P-type thermal sensor, for example. Also, the sensor IF, as well as the sensor 1C according to the third variation of the first embodiment, includes no smoke detection unit 4 and determines, only by detecting heat, whether or not a fire is present.

**[0124]** In this embodiment, each heat sensitive element 30 (chip thermistor) is also arranged, when the open area 70 inside an associated opening 7 (side inlet 7A; lateral port) is viewed from the external space SP2, to fall within the open area 70. The shielding member V1 is configured to partially shut off the open area 70 and provided in a region closer to the external space SP2 than the heat sensitive element 30 (chip thermistor) is.

**[0125]** The shielding member V1 includes a pair of pillars V11. In this embodiment, the shielding member V1 is made up of the pair of pillars V11. Each pillar V11 is elongated in the upward/downward direction (e.g., along the thickness of the board 2 in this embodiment). The pillars V11 are formed integrally with the front cover 51 of the housing 5. Specifically, a first end (upper end) of each pillar V11 is connected to the circular cylindrical body 510 of the housing 5 while a second end (lower end) of each pillar V11 is connected to the base portion 511. Thus, each pillar V11 extends from the upper edge through the lower edge of an associated opening 7 (side inlet 7A).

**[0126]** The pair of pillars V11 are arranged to be spaced apart from each other by a predetermined gap distance L1 in a direction D1 (e.g., the rightward/leftward direction in this embodiment) perpendicular to the arrangement direction in which the back cover 52 and the front cover 51 are arranged, when the open area 70 is viewed from the external space SP2. In the following description, the back cover 52 is supposed to correspond to a first cover and the front cover 51 is supposed to correspond to a second cover, for example. Conversely, the back cover 52 may correspond to the second cover and the front cover 51 may correspond to the first cover.

**[0127]** In this embodiment, the predetermined gap distance L1 is a gap distance defined to prevent a test finger from slipping into the gap. As used herein, the "test finger" is supposed to be the pseudo-finger defined in Appendix 4, 1(2)(iii) of "Electrical Appliances and Materials Safety Act" of Japan, for example.

**[0128]** The heat sensitive element 30 is located in the direction D1 between the pair of pillars V11 (see FIG. 12A) when the open area 70 is viewed from the external space SP2. In other words, the heat sensitive element 30 is exposed between the pair of pillars V11.

**[0129]** As can be seen, the sensor IF further includes the shielding member V1, thus reducing the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being

obstructed.

**[0130]** Each pillar V11 has a guide surface V2 for guiding the gas flow coming from the external space SP2 toward the heat sensitive element 30 (chip thermistor) as shown in FIG. 12B. In this embodiment, each pillar V11 has a generally semi-elliptical cross-sectional shape as taken along a horizontal plane and a curved surface thereof corresponds to the guide surface V2. The tip of the semi-elliptical shape points toward the heat sensitive element 30. This further reduces the chances of the influx of heat through the openings 7 being obstructed by the shielding member V1.

**[0131]** Next, a first variation of this embodiment will be described. In the above-described example shown in FIGS. 12A and 12B, the shielding member V1 has two pillars V11. However, the number of the pillars of the shielding member V1 is not limited to any particular number. FIGS. 13A and 13B illustrate a sensor 1G according to a first variation. In the sensor 1G according to the first variation, the shielding member V1 has three pillars, which is a major difference from the sensor IF.

**[0132]** The sensor 1G according to the first variation is implemented as, for example, a P-type thermal sensor. The protruding portion 23 of the board 2 of the sensor IF protrudes slightly obliquely with respect to the radius of the housing 5 when viewed in the upward/downward direction (see FIG. 12B). On the other hand, the protruding portion 23 of the board 2 of the sensor 1G protrudes along the radius of the housing 5 (see FIG. 13B).

**[0133]** The shielding member V1 of the sensor 1G includes three pillars (namely, a pair of first pillars V12 provided on the right and on the left and a second pillar V13 provided in the middle). In this variation, the shielding member V1 is made up of the three pillars. Each of the pair of first pillars V12 and the second pillar V13 is elongated in the upward/downward direction (e.g., along the thickness of the board 2 in this variation). The pair of first pillars V12 and the second pillar V13 are formed integrally with the front cover 51 of the housing 5. Specifically, a first end (upper end) of each pillar is connected to the circular cylindrical body 510 of the housing 5 while a second end (lower end) of each pillar is connected to the base portion 511. Thus, each pillar extends from the upper edge through the lower edge of an associated opening 7.

**[0134]** The pair of first pillars V12 and the second pillar V13 are arranged to be spaced apart from each other by a predetermined gap distance L2 in the direction D1 (e.g., the rightward/leftward direction in this variation), when the open area 70 is viewed from the external space SP2. In this variation, the predetermined gap distance L2 is also a gap distance defined to prevent a test finger from slipping into the gap.

**[0135]** The heat sensitive element 30 is located in the direction D1 between the pair of first pillars V12 (see FIG. 13A) when the open area 70 is viewed from the external space SP2. Nevertheless, the heat sensitive element 30 is located in a region where the heat sensitive element

30 overlaps with the second pillar V13 when the open area 70 is viewed from the external space SP2. In other words, the heat sensitive element 30 is provided in a region where the heat sensitive element 30 is hidden behind the second pillar V13.

**[0136]** As can be seen, the sensor 1G further includes the shielding member V1 including three pillars, thus further reducing the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being obstructed.

**[0137]** Each of the pair of first pillars V12 has a guide surface V2 for guiding the gas flow coming from the external space SP2 toward the heat sensitive element 30 (chip thermistor) as shown in FIG. 13B. In this variation, each of the pair of first pillars V12 has a generally race-track cross-sectional shape, which is elongated along the outer edge of the housing 5, as taken along a horizontal plane and has a pair of semi-arced curve surfaces, serving as the guide surfaces V2, on the right and on the left. This further reduces the chances of the influx of heat through the openings 7 being obstructed by the shielding member V1. In this variation, the second pillar V13 has a generally rectangular cross-sectional shape as taken along a horizontal plane. However, this is only an example of the present disclosure and should not be construed as limiting. Alternatively, the second pillar V13, as well as the first pillars V12, may also have the racetrack shape and have the guide surfaces V2.

**[0138]** FIG. 13C illustrates another example of the sensor 1G according to the first variation. In this example, each of the pair of first pillars V12 has a generally trapezoidal cross-sectional shape as taken along a horizontal plane. Each first pillar V12 is configured such that the shorter side out of the two parallel sides of the trapezoid is located closer to the heat sensitive element 30 and the longer side thereof is located closer to the external space SP2. In particular, a first surface V121, facing the middle second pillar V13, of each first pillar V12 and a second surface V122, opposite from the first surface V121, of the first pillar V12 are sloped surfaces which are sloped toward the heat sensitive element 30. The tilt angle defined by the second surface V122 with respect to the radius of the housing 5 is larger than the tilt angle defined by the first surface V121 with respect to the radius of the housing 5. The middle second pillar V13 has a bulletlike cross-sectional shape, which is elongated along the radius of the housing 5, as taken along a horizontal plane. The second pillar V13 has a semi-arced portion facing the heat sensitive element 30. In this example, the first surface V121, the second surface V122, and the end surface with the semi-arced cross section correspond to the guide surface V2. That is to say, in this example, each of the pair of first pillars V12 has the guide surface V2. According to this example, providing the guide surface V further reduces the chances of the influx of heat through the openings 7 being obstructed by the shielding member V1.

**[0139]** Next, a second variation of the second embodiment will be described. FIGS. 14A-14C and FIG. 15 illustrate a sensor 1H according to the second variation. The sensor 1H according to the second variation may be implemented as, for example, an R-type thermal sensor. The protruding portion 23 of the board 2 of the sensor 1H protrudes outward along the radius of the housing 5.

**[0140]** The shielding member V1 of the sensor 1H according to the second variation includes a pair of first projections V14 and a single second projection V15. In this variation, the shielding member V1 is made up of the pair of first projections V14 and the second projection V15. Each of the pair of first projections V14 protrudes from the back cover 52 (first cover), which covers the board 2 from one side along the thickness of the board 2 (e.g., from over the board 2 in this variation), toward the front cover 51 (second cover). The front cover 51 covers the board 2 from the other side, opposite from the one side, along the thickness of the board 2 (e.g., from under the board 2 in this variation). The second projection V15 protrudes from the front cover 51 toward the back cover 52. Each of the pair of first projections V14 and the second projection V15 is elongated in the upward/downward direction (e.g., along the thickness of the board 2 in this variation).

**[0141]** The pair of first projections V14 are formed integrally with the back cover 52 as shown in FIG. 15. Specifically, the pair of first projections V14 protrudes continuously downward from a peripheral edge portion of the lower surface of the back cover 52. Note that the respective tips of the pair of first projections V14 are out of contact with the front cover 51 with a gap left with respect to the front cover 51.

**[0142]** The pair of first projections V14 are arranged to be spaced apart from each other by a predetermined gap distance L3 in the direction D1 when the open area 70 is viewed from the external space SP2. In this variation, the predetermined gap distance L3 is also a gap distance defined to prevent a test finger from slipping into the gap. The heat sensitive element 30 is located in the direction D1 between the pair of first projections V14 (see FIG. 14A) when the open area 70 is viewed from the external space SP2.

**[0143]** The second projection V15 is arranged in the direction D1 in the middle between the pair of first projections V14. In other words, each of the pair of first projections V14 is arranged to be shifted in the direction D1 with respect to the second projection V15 when the open area 70 is viewed from the external space SP2. This further reduces the chances of the influx of heat through the openings 7 being obstructed by the shielding member V1.

**[0144]** The second projection V15 is formed integrally with the front cover 51. Specifically, the second projection V15 protrudes continuously upward from a peripheral edge portion of the upper surface of the front cover 51. The tip of the second projection V15 is out of contact with the upper edge of the opening 7 with a gap left with re-

spect to the upper edge.

**[0145]** The second projection V15 is located at the same position in the direction D1 as the chip thermistor as shown in FIG. 14A when open area 70 is viewed from the external space SP2. Nevertheless, the protrusion height of the second projection V15 is defined such that the chip thermistor is exposed at least partially. Specifically, its protrusion height is defined such that the tip of the second projection V15 does not exceed the upper surface of the chip thermistor. In this variation, the tip of the second projection V15 is located under the lower surface of the board 2 and the heat sensitive element 30 is exposed between the pair of first projections V14 without being hidden behind the second projection V15.

**[0146]** As can be seen, defining the protrusion height of the second projection V15 such that the chip thermistor is exposed at least partially reduces the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being obstructed.

**[0147]** Each of the pair of first projections V14 also has a guide surface V2 as shown in FIG. 14B. In this variation, each of the pair of first projections V14 has an elliptical cross-sectional shape, which is elongated along the radius of the housing 5, as taken along a horizontal plane, and has a pair of curved surfaces as the guide surfaces V2 on the right and on the left. This further reduces the chances of the influx of heat through the openings 7 being obstructed by the shielding member V1. In particular, setting the width of each of the first projections V14 at a relatively small value further reduces the chances of the influx of the heat being obstructed.

**[0148]** Meanwhile, the second projection V15 also has a guide surface V2 as shown in FIG. 14C. The second projection V15 is formed to have a generally triangular shape when viewed in the arrangement direction in which the pair of first projections V14 are arranged side by side. In particular, when viewed in the arrangement direction in which the pair of first projections V14 are arranged side by side, the second projection V15 has a curved surface V150, which has a generally arced, sloped recess that is provided to face the internal space SP1. This curved surface V150 also corresponds to the guide surface V2. The heated gas flow may be guided toward the chip thermistor, which is located above the second projection V15, by colliding against the guide surface V2.

**[0149]** As can be seen, the sensor 1H provided with the shielding member V1 including the three projections further reduces the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being obstructed.

**[0150]** Optionally, the shielding member V1 may further include, between the pair of first projections V14, for example, an additional first projection V14. The additional first projection V14 and the second projection V15 may protrude such that their respective tips face each other.

In that case, the additional first projection V14, as well as the second projection V15, suitably has its protrusion height defined such that the chip thermistor is exposed at least partially.

**[0151]** Next, a third variation of the second embodiment will be described. FIG. 16 illustrates a sensor 1I according to the third variation. The sensor 1I according to the third variation may be implemented as, for example, an R-type thermal sensor.

**[0152]** The shielding member V1 of the sensor 1I includes a pair of first projections V16, which are formed integrally with the back cover 52 just like the pair of first projections V14 of the sensor 1H according to the second variation. The pair of first projections V16 protrudes from the back cover 52 toward the front cover 51. The heat sensitive element 30 is arranged in the direction D1 between the pair of first projections V16 when the open area 70 is viewed from the external space SP2.

**[0153]** The shielding member V1 of the sensor 1I further includes a pair of second projections V17, which are formed integrally with the front cover 51 just like the second projection V15 of the sensor 1H according to the second variation. The pair of second projections V17 protrudes from the front cover 51 toward the back cover 52. Note that the pair of second projections V17 protrudes such that their respective tips face one to one the respective tips of the pair of first projections V16. In other words, a gap is left between each of the first projections V16 and an associated one of the second projections V17 which faces the first projection V16.

**[0154]** In addition, the shielding member V1 of the sensor 1I further includes a pillar V18. The pillar V18, as well as the pillar V13 of the sensor 1G according to the first variation, is formed integrally with the front cover 51 of the housing 5. The heat sensitive element 30 is located in a region where the heat sensitive element 30 overlaps with the pillar V18 when the open area 70 is viewed from the external space SP2. In other words, the heat sensitive element 30 is positioned to be hidden behind the pillar V18.

**[0155]** Each of the pair of first projections V16 and the pillar V18 are arranged to be spaced apart from each other by a predetermined gap distance L4 in the direction D1, when the open area 70 is viewed from the external space SP2. In this variation, the predetermined gap distance L4 is also a gap distance defined to prevent a test finger from slipping into the gap.

**[0156]** As can be seen, the sensor 1I provided with the shielding member V1 including the four projections and the one pillar further reduces the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being obstructed.

**[0157]** Although not shown, the shielding member V1 of the sensor 1I suitably has the guide surface V2 as well.

**[0158]** Next, a fourth variation of the second embodiment will be described. FIGS. 17A and 17B illustrate a

sensor 1J according to a fourth variation. The sensor 1J according to the fourth variation may be implemented as, for example, an R-type thermal sensor.

**[0159]** The shielding member V1 of the sensor 1J includes only one pillar V19. The pillar V19, as well as the second pillar V13 of the sensor 1G according to the first variation, is also formed integrally with the front cover 51 of the housing 5. The heat sensitive element 30 is located at a position where the heat sensitive element 30 overlaps with the pillar V19 when the open area 70 is viewed from the external space SP2. In other words, the heat sensitive element 30 is positioned to be hidden behind the pillar V19.

**[0160]** The pillar V19 has a guide surface V2 as shown in FIG. 17B. In this variation, the pillar V19 has a tapered cross-sectional shape, which is pointed toward the internal space SP1, as taken along a horizontal plane, and the tapered surface corresponds to the guide surface V2. In addition, the cross-sectional shape of the pillar V19 has a semi-arc shape on the right and on the left. These right and left surfaces also correspond to the guide surfaces V2.

**[0161]** As can be seen, the sensor 1J, provided with only one pillar V19, still reduces the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of the influx of heat through the openings 7 being obstructed. Note that if it is important to reduce the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally, then the numbers of the projections and pillars provided for the shielding member V1 are suitably equal to or greater than two as in the sensors 1F-1I.

(Third embodiment)

**[0162]** Next, a sensor 1K according to a third embodiment will be described with reference to FIGS. 18A-18C. In the following description, any constituent element of this third embodiment, having substantially the same function as a counterpart of the first embodiment described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. In the sensor 1K according to this embodiment, the outer surface 53 includes a first surface 531 formed in a tapered shape as will be described later, which is a major difference from the sensor (1, 1A-1E) according to the first embodiment (including variations thereof). Optionally, the first surface 531 having the tapered shape is applicable as appropriate to the sensor (1, 1A-1E) according to the first embodiment or the sensor (1F-1J) according to the second embodiment. The sensor 1K shown in FIGS. 18A-18C may be implemented as, for example, an R-type thermal sensor. Also, the sensor 1K, as well as the sensor 1C according to the third variation of the first embodiment, includes no smoke detection unit 4 and determines, only by detecting heat, whether or not a fire is present. In

addition, the sensor 1K, as well as the sensor 1H according to the second variation of the second embodiment, includes a plurality of shielding members V1.

**[0163]** The openings 7 of the sensor 1K according to this embodiment, as well as the sensor 1C (see FIGS. 8A and 8B) and sensor 1D (see FIGS. 9A and 9B) according to the first embodiment, include the inlet port 7B. That is to say, the openings 7 include not only the six side inlets (lateral ports) 7A but also the inlet port 7B as well. The inlet port 7B is provided through the outer surface 53, opposite from the structural component X1 on which the sensor 1K is installed, of the housing 5 (i.e., the lower surface of the front cover 51). In this embodiment, the inlet port 7B may be provided in the central area of the outer surface 53, for example. The inlet port 7B penetrates through the front cover 51 in the thickness direction. The inlet port 7B has a generally circular opening.

**[0164]** In the sensor 1K, part of the board 2 is exposed through the inlet port 7B as shown in FIG. 18B. Specifically, the board 2 has, in the central area thereof, a port 25 that penetrates through the board 2 in the thickness direction. The port 25 has a generally circular opening. The port 25 is arranged to be substantially laid on top of the inlet port 7B. The board 2 has a pair of projections 26, which are provided at an opening edge of the port 25 to protrude toward each other. The respective tips of the pair of projections 26 are exposed through the inlet port 7B. In addition, on the upper surface of each projection 26 of the board 2, provided is the heat sensitive element 30 (chip thermistor). That is to say, the sensor 1K includes not only a plurality of (e.g., six in the example illustrated in FIG. 18B) heat sensitive elements 30 provided in the vicinity of the side inlets (lateral ports) 7A but also two more heat sensitive elements 30 provided in the vicinity of the inlet port 7B. In addition, to reduce the chances of the heat generated by each heat sensitive element 30 being transferred through the board 2 in the vicinity of the heat sensitive element 30 to cause a decrease in the temperature of the heat sensitive element 30, the board 2 has generally triangular through holes 31.

**[0165]** Providing the inlet port 7B for the openings 7 of the sensor 1K allows the heat of the gas that has flowed in through the inlet port 7B to be detected, thus increasing the responsivity to detection of heat.

**[0166]** In this embodiment, the outer surface 53 of the sensor 1K according to this embodiment has the first surface 531 surrounding the inlet port 7B and a second surface 532 located outside of the first surface 531. In this embodiment, the second surface 532 is located around and outside of the first surface 531. In particular, the first surface 531 is formed in a tapered shape, which is sloped, at a different tilt angle from the second surface 532, toward the structural component X1 (i.e., upward) as the distance to the inlet port 7B decreases as shown in FIG. 18C. In this embodiment, the outer surface 53 further has a third surface 533 as an example. The third surface 533 is located outside of the first surface 531 but inside of the

second surface 532. In a front view of the outer surface 53, each of the first, second, and third surfaces 531-533 has a doughnut shape. Regarding the dimensions as measured along the radius of the outer surface 53, the second surface 532 may have the largest dimension, the third surface 533 may have the second largest dimension, and the first surface 531 may have the smallest dimension. However, this is only an example of the present disclosure and should not be construed as limiting.

**[0167]** The first surface 531 may define a tilt angle  $\theta_1$  of 23 degrees, for example, with respect to a horizontal plane. The second surface 532 may define a tilt angle  $\theta_2$  falling within the range from 0 degrees to 1 degree, for example, with respect to the horizontal plane. The third surface 533 may define a tilt angle  $\theta_3$  of 8 degrees, for example, with respect to the horizontal plane.

**[0168]** As can be seen, in the sensor 1K according to this embodiment, the outer surface 53 has the first surface 531 and the second surface 532, thus further accelerating the influx of heat into the inlet port 7B when a fire is present (as indicated by the arrow in FIG. 18C). In particular, in the sensor 1K, the outer surface 53, including the third surface 533, is sloped in two stages, thus accelerating the influx of heat into the inlet port 7B even more effectively.

**[0169]** The regulations require that this type of sensor be subjected to an operation test at regular intervals (e.g., once in six months) to see if the sensor operates normally. As shown in FIG. 19A, a person 600 in charge of operation test conducts, using a predetermined (heating) tester 900, a heating test on the heat sensitive elements 30 of the sensor 1K installed on the structural component X1 (e.g., the ceiling in the example illustrated in FIG. 19A).

**[0170]** The tester 900 includes: a heat source 910 such as a Hakukin warmer; a body 920, which has a generally circular cylindrical shape with an open top and which houses the heat source 910 therein; and a supporting rod 930 for supporting the body 920 thereon. When the operation test is conducted, the body 920 is positioned to cover the base portion 51 and openings 7 of the front cover 51 of the sensor 1K from under the sensor 1K. If the heat sensitive elements 30 and other members operate normally, the sensor 1K will operate, on receiving a heat flow from the heat source 910, in the same way as when detecting a fire.

**[0171]** In this embodiment, implementing the heat sensitive elements 30 as chip thermistors mounted on the board 2 contributes to reducing the overall size (the thickness, among other things) of the sensor (1, 1A-1K) as already described for the first embodiment. Meanwhile, downsizing the sensor could cause a decline in the positioning stability of the tester 900 with respect to the sensor during the operation test.

**[0172]** Thus, to overcome this problem, the housing 5 of the sensor 1K according to this embodiment has a plurality of (e.g., six) projections W1 (see FIGS. 18A and

18B; note that only four out of the six projections W1 are shown in FIG. 18A). The plurality of projections W1 protrudes from an edge portion (e.g., an upper edge portion in this embodiment) of the openings 7 away from the structural component X1, on which the sensor 1K is installed (e.g., downward). The plurality of projections W1 may be arranged at regular intervals along the circumference of the housing 5 when viewed from under the sensor 1K.

**[0173]** The plurality of projections W1 is configured to come into contact with a peripheral edge portion 901 of the tester 900 (see FIG. 19B) when the tester 900 for conducting a heating test on the heat sensitive elements 30 is positioned to cover the housing 5. Providing these projections W1 allows the tester 900 to be positioned with good stability with respect to the housing 5. That is to say, this increases the chances of the projections W1 making a point contact with the peripheral edge portion 901. This may reduce the backlash compared to a situation where the housing 5 makes a plane contact with the peripheral edge portion 901 with no projections W1 provided.

**[0174]** In this embodiment, the plurality of projections W1 protrude downward from the lower peripheral edge of the circular cylindrical body 510. In addition, the plurality of projections W1 are located at the same positions along the circumference of the housing 5 as the plurality of beams 512 so that the plurality of projections W1 correspond one to one to the plurality of beams 512. Specifically, each projection W1 is formed integrally with a part (upper part) of its corresponding beam 512. In other words, each projection W1 also serves as a reinforcing part for its corresponding beam 512. However, this is only an example of the present disclosure and should not be construed as limiting. Alternatively, each projection W1 does not have to serve as a reinforcing part for its corresponding beam 512. Each projection W1 may also be shifted along the circumference of the housing 5 from its corresponding beam 512.

**[0175]** Note that the number of the projections W1 provided is not limited to any particular number. For example, only one projection W1 may be provided. Providing only one projection W1 also allows the tester 900 to be positioned with more stability than in a situation where the housing 5 makes a plane contact with the peripheral edge portion 901 of the tester 900.

**[0176]** FIG. 20 illustrates a sensor 1L as a variation of the third embodiment. In the sensor 1L according to this variation, the outer surface 53 also has the first surface 531 with the tapered shape. The sensor 1L may be implemented as, for example, a P-type thermal sensor. In particular, the sensor 1L, as well as the sensor 1G according to the first variation of the second embodiment, includes two shielding members V1, each including three pillars (namely, the pair of first pillars V12 provided on the right and on the left and the second pillar V13 provided in the middle). In FIG. 20, only one of the two shielding members V1 is illustrated. The other shielding member

V1 is located on the rear.

**[0177]** In addition, the sensor 1L also includes a plurality of (e.g., four) projections W1 (see FIG. 20; only three of the four projections W1 are shown there), which are configured to come into contact with the peripheral edge portion 901 (see FIG. 19B) of the tester 900. In this variation, at least one projection W1, out of the four projections W1, is formed integrally with a part (upper part) of the second pillar V13 provided in the middle of the shielding member V1 in order to serve as a reinforcing part for the second pillar V13. That is to say, the four projections W1 of the sensor 1L are arranged at the same positions along the circumference of the housing 5 as the two beams 512 and the two second pillars V13 (including the second pillar V13 of the shielding member V1 provided opposite from the shielding member V1 shown in FIG. 20), respectively, so that the four projections W1 correspond one to one to the two beams 512 and the two second pillars V13.

(Fourth embodiment)

**[0178]** Next, a sensor 1M according to a fourth embodiment will be described with reference to FIGS. 21A and 21B. In the following description, any constituent element of this fourth embodiment, having substantially the same function as a counterpart of the first embodiment described above, will be designated by the same reference numeral as that counterpart's, and description thereof will be omitted as appropriate herein. The sensor 1M shown in FIGS. 21A and 21B may be implemented as an R-type thermal sensor, for example. Also, the sensor 1M, as well as the sensor 1C according to the third variation of the first embodiment, includes no smoke detection unit 4 and determines, only by detecting heat, whether or not a fire is present. In addition, the sensor 1M includes a plurality of shielding members V1, each including three pillars.

**[0179]** The sensor 1M includes a mounting base 100B for installing the body 100A thereof on a structural component X1 (e.g., a ceiling in the example illustrated in FIG. 21). Optionally, the mounting base 100B is also applicable as appropriate to the sensor (1, 1A-1M) according to the first embodiment, the sensor (1F-1J) according to the second embodiment, or the sensor (1K, 1L) according to the third embodiment.

**[0180]** The mounting base 100B is formed in the shape of a generally compressed circular cylinder, of which the lower surface is open. The mounting base 100B may be fixed onto the surface of the structural component X1 by screwing, for example. The structural component X1 has a hole, through which cables (including power cables and signal cables) are extended from the back of the structural component X1. The mounting base 100B has, through a bottom portion 106 thereof, a through hole 103 (see FIG. 21B), through which the cables extended from the hole of the structural component X1 are passed toward the body 100A.

**[0181]** In addition, the mounting base 100B also includes an outer peripheral wall 104 and a rim portion 105 protruding outward from the outer peripheral wall 104. The outer peripheral wall 104 is configured to be fitted into a recess formed, in the upper part of the body 100A, by the circular cylindrical body 510 and the back cover 52 (see FIG. 1). Although not described in detail, the mounting base 100B includes an engageable portion, with which an engaging portion of the back cover 52 is brought into engagement by turning the sensor 1M clockwise (i.e., to the right) around the axis with the outer peripheral wall 104 fitted into the recess of the body 100A. Bringing the engaging portion of the back cover 52 into engagement with the engageable portion allows the body 100A to be fixed onto the mounting base 100B.

**[0182]** In this sensor 1M, when the body 100A is fixed onto the mounting base 100B, the outer peripheral surface of the rim portion 105 becomes substantially flush with the outer peripheral surface of the circular cylindrical body 510 as shown in FIG. 21A. This allows a sensor with good appearance to be provided.

**[0183]** The mounting base 100B is a type of base unit that requires the sensor 1M to be directly mounted on the surface of the structural component X1. Alternatively, according to a variation of this embodiment, the sensor 1M may include an embedded base 100C as shown in FIGS. 22A and 22B, instead of the mounting base 100B. The embedded base 100C is a type of base unit that requires the sensor 1M to be embedded with respect to the structural component X1.

**[0184]** The embedded base 100C includes: a base body 107 to be inserted into an embedding hole provided for the structural component X1; and a decorative portion 108 formed integrally with the base body 107.

**[0185]** The base body 107 is formed in the shape of a compressed circular cylinder, of which the lower surface is opened. In addition, the embedded base 100C further includes a mounting bracket (which may be either a first mounting bracket T1 or a second mounting bracket T2 to be described later) for fixing the sensor 1M onto the structural component X1 with the sensor 1M inserted into the hole of the structural component X1, for example. The base body 107 has, through its bottom portion 109, a through hole 110 (see FIG. 22B) which allows cables on the back of the structural component X1 to pass through toward the body 100A.

**[0186]** The base body 107 has a recess 111, of which the inside diameter is slightly larger than the outside diameter of the body 100A. That is to say, the body 100A may be housed in the recess 111. In this embodiment, the recess 111 is deep enough to house approximately a half in the upward/downward direction (i.e., an upper half) of the circular cylindrical body 510 therein.

**[0187]** The decorative portion 108 forms a rim that protrudes outward from the lower end of the base body 107. With the base body 107 inserted into the hole of the structural component X1, the decorative portion 108 is located under, and exposed on, the surface of the structural com-

ponent X1.

**[0188]** Although not described in detail, the embedded base 100C includes an engageable portion, with which an engaging portion of the back cover 52 is brought into engagement by turning the sensor 1M clockwise (i.e., to the right) around the axis with the body 100A fitted into the recess 111 of the base body 107, for example. Bringing the engaging portion of the back cover 52 into engagement with the engageable portion allows the body 100A to be fixed onto the embedded base 100C.

**[0189]** The sensor 1M may have its protrusion height, as measured from the surface of the structural component X1, reduced with the body 100A fixed onto the embedded base 100C. This allows a sensor with good appearance to be provided.

**[0190]** Next, it will be described with reference to FIG. 23A how to mount the embedded base 100C onto the structural component X1 using a pair of first mounting brackets T1. The embedded base 100C includes the pair of first mounting brackets T1. Note that only the structural component X1 has its cross section shown in FIG. 23A for the sake of convenience of description. Each of the pair of first mounting brackets T1 includes: a fixing screw T11; and a fixing piece T12 in the shape of a partially bent leaf spring. The fixing piece T12 has a screw hole into which the fixing screw T11 is screwed. The fixing piece T12 is fixed temporarily, over the base body 107, onto the fixing screw T11 with the fixing screw T11 inserted into a through hole of the bottom portion 109 of the base body 107 from under the bottom portion 109. In other words, the bottom portion 109 is clamped between a flat portion T120 of the fixing piece T12 and the head of the fixing screw T11.

**[0191]** To mount the embedded base 100C onto the structural component X1, first, the respective fixing screws T11 are loosened with a tool such as a screwdriver to cancel the clamped state. This allows the respective fixing pieces T12 to be tilted inward along with the fixing screws T11 (see the fixing pieces T12 illustrated in phantom lines in FIG. 23A). Next, with the respective fixing pieces T12 kept tilted inward, the base body 107 is inserted into a hole X11 of the structural component X1. Thereafter, the respective fixing screws T11 are tightened with a tool such as a screwdriver, thereby causing each of the fixing pieces T12 to turn down outward around the flat portion T120, which is in contact with the base body 107, as a fulcrum. This brings its tip T121 (constituting a point of action) into contact with the back surface of the structural component X1. Then, further tightening the respective fixing screws T11 causes the structural component X1 to be vertically clamped by the respective tips T121 of the fixing pieces T12 and the decorative portion 108. As a result, the embedded base 100C is fixed onto the structural component X1.

**[0192]** Next, it will be described with reference to FIG. 23B how to mount the embedded base 100C onto the structural component X1 using a pair of second mounting brackets T2. The embedded base 100C includes the pair

of second mounting brackets T2. Note that only the structural component X1 has its cross section shown in FIG. 23B for the sake of convenience of description. Each of the pair of second mounting brackets T2 includes: a fixing screw T21; and a fixing piece T22 in the shape of a flat rectangular plate. The fixing piece T22 has a screw hole into which the fixing screw T21 is screwed. The fixing piece T22 is fixed temporarily, over the decorative portion 108, onto the fixing screw T21 with the fixing screw T21 inserted into a through hole of the decorative portion 108 from under the decorative portion 108.

**[0193]** To mount the embedded base 100C onto the structural component X1, first, each fixing screw T21 is loosened with a tool such as a screwdriver, thereby turning the fixing piece T22 such that its tip faces inward. Next, with this state maintained, the base body 107 is inserted into the hole X11 of the structural component X1. Thereafter, each fixing screw T21 is tightened with a tool such as a screwdriver, thereby causing the tip of the fixing piece T22 to face outward. In addition, this also causes the fixing piece T22 to be brought down toward the back surface of the structural component X1 to substantially make a plane contact with the back surface of the structural component X1. Then, further tightening the respective fixing screws T21 causes the structural component X1 to be vertically clamped by the fixing pieces T22 and the decorative portion 108. As a result, the embedded base 100C is fixed onto the structural component X1.

**[0194]** Note that the first mounting brackets T1 and the second mounting brackets T2 are only examples and should not be construed as limiting. That is to say, these are not the only mounting brackets for use to fix the embedded base 100C onto the structural component X1. Likewise, the mounting methods described above are also only examples and should not be construed as limiting.

#### (4) Resume

**[0195]** As can be seen from the foregoing description, a sensor (1, 1A-1M) according to a first aspect includes a board (2), a heat sensitive element (30), and a housing (5). The housing (5) houses the board (2). The housing (5) has a flow channel (6) provided in an internal space (SP1) thereof and configured to allow a gas to flow there-through, and an opening (7) connecting the flow channel (6) to an external space (SP2) outside of the housing (5). The heat sensitive element (30) is implemented as a chip thermistor mounted on the board (2) and configured to detect heat of the gas that has flowed in through the opening (7). According to the first aspect, the heat sensitive element (30) is implemented as a chip thermistor mounted on the board (2), thus contributing to reducing the overall size of the sensor (1, 1A-1M).

**[0196]** In a sensor (1, 1A-1M) according to a second aspect, which may be implemented in conjunction with the first aspect, a surface (such as a first surface 21) of

the board (2) is suitably exposed at least partially to the flow channel (6). The second aspect increases the chances of the heat sensitive element (30) being exposed to the gas flowing through the flow channel (6), thus contributing to downsizing while further improving the heat detection performance.

**[0197]** In a sensor (1, 1A-1M) according to a third aspect, which may be implemented in conjunction with the first or second aspect, the chip thermistor is suitably arranged, when an open area (70) of the opening (7) is viewed from the external space (SP2), to fall within the open area (70). The third aspect further increases the chances of the heat sensitive element (30) being exposed to the gas flowing through the flow channel (6), thus contributing to downsizing while further improving the heat detection performance.

**[0198]** In a sensor (1, 1A-1M) according to a fourth aspect, which may be implemented in conjunction with the third aspect, the chip thermistor is suitably located at the following position. Specifically, when the open area (70) is viewed from the external space (SP2), the chip thermistor is suitably located, inside the open area (70), at a middle of the open area (70) in a direction perpendicular to the surface (such as the first surface 21) of the board (2). The fourth aspect further increases, compared to a situation where the chip thermistor is located close to one end of the open area (70) in that direction, for example, the chances of the heat sensitive element (30) being exposed to the gas flowing through the flow channel (6).

**[0199]** In a sensor (1, 1A-1M) according to a fifth aspect, which may be implemented in conjunction with any one of the first to fourth aspects, the flow channel (6) includes: a first channel (61) located closer to the opening (7); and a second channel (62) connected to the first channel (61) and located closer to a central area of the internal space (SP1). The chip thermistor is suitably provided in the first channel (61). The fifth aspect increases, compared to a situation where the chip thermistor is provided in the second channel (62), for example, responsiveness to heat detection.

**[0200]** In a sensor (1, 1A-1M) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, the flow channel (6) includes: a first channel (61) located closer to the opening (7); and a second channel (62) connected to the first channel (61) and located closer to a central area of the internal space (SP1). The first channel (61) suitably has a smaller open cross-sectional area than the second channel (62). The sixth aspect allows the gas that has flowed into the flow channel (6) through the opening (7) to be accelerated to flow from the first channel (61) toward the second channel (62).

**[0201]** In a sensor (1, 1A-1M) according to a seventh aspect, which may be implemented in conjunction with the sixth aspect, the housing (5) suitably has an installation surface (55) to face a structural component (X1) on which the sensor (1, 1A-1M) is to be mounted. The sec-

ond channel (62) suitably expands toward the installation surface (55) as a distance, measured in a direction pointing from the first channel (61) toward the central area, decreases. The seventh aspect allows a gas flow from the first channel (61) toward the second channel (62) to be produced more effectively.

**[0202]** A sensor (1, 1A-1M) according to an eighth aspect, which may be implemented in conjunction with any one of the first to seventh aspects, suitably further includes a smoke detection unit (4) arranged in the central area of the internal space (SP1) and configured to detect smoke. According to the eighth aspect, not only heat but also smoke may be detected as well, thus contributing to reducing the overall size of the sensor (1, 1A-1M) while improving the fire sensing performance.

**[0203]** In a sensor (1, 1A-1M) according to a ninth aspect, which may be implemented in conjunction with the eighth aspect, the smoke detection unit (4) is suitably arranged on the same side as a surface (such as a first surface 21) of the board (2) on which the chip thermistor is mounted. The ninth aspect contributes to reducing the overall size of the sensor (1, 1A-1M) while further improving the fire sensing performance.

**[0204]** In a sensor (1, 1A-1M) according to a tenth aspect, which may be implemented in conjunction with the eighth or ninth aspect, the housing (5) suitably has an installation surface (55) to face a structural component (X1) on which the sensor (1, 1A-1M) is to be mounted. The smoke detection unit (4) is suitably arranged on one surface selected from the group consisting of two surfaces that are a surface (such as a first surface 21) of the board (2) and a back surface (such as a second surface 22) thereof opposite from the surface. The one surface is suitably located closer to the installation surface (55) than the other of the two surfaces is. The tenth aspect further contributes to downsizing, compared to a situation where the smoke detection unit (4) is arranged on the surface located more distant from the installation surface (55).

**[0205]** In a sensor (1, 1A-1M) according to an eleventh aspect, which may be implemented in conjunction with any one of the eighth to tenth aspects, the housing (5) suitably includes, inside the internal space (SP1), a single or a plurality of wall members (control plates 522). The single or plurality of wall members (control plates 522) suitably guides the gas toward either the heat sensitive element (30) or the smoke detection unit (4). The eleventh aspect allows the fire sensing performance to be further improved.

**[0206]** In a sensor (1, 1A-1M) according to a twelfth aspect, which may be implemented in conjunction with any one of the eighth to eleventh aspects, the housing (5) suitably has an installation surface (55) to face a structural component (X1) on which the sensor (1, 1A-1M) is to be mounted. The smoke detection unit (4) includes: an optical element (41) to emit light; a photosensitive element (42) to receive the light emitted from the optical element (41); and a labyrinth structure (43). In the laby-

rinth structure (43), the optical element (41) and the photosensitive element (42) are arranged to avoid facing each other. When measured along thickness of the board (2) (i.e., in the upward/downward direction), a middle (PI) of an internal space of the labyrinth structure (43) is suitably located between the chip thermistor and the installation surface (55). The twelfth aspect allows the sensor (1, 1A-1M) for detecting not only heat but also smoke to have a further reduced overall size as well as further improved fire sensing performance.

**[0207]** In a sensor (1, 1A-1M) according to a thirteenth aspect, which may be implemented in conjunction with any one of the first to twelfth aspects, the chip thermistor is suitably arranged, when an open area (70) of the opening (7) is viewed from the external space (SP2), to fall within the open area (70). The sensor (1, 1A-1M) suitably further includes a shielding member (VI) provided closer to the external space (SP2) than the chip thermistor is and configured to partially shut off the open area (70). According to the thirteenth aspect, providing the shielding member (VI) may reduce the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while reducing the chances of influx of heat through the opening (7) being obstructed.

**[0208]** In a sensor (1, 1A-1M) according to a fourteenth aspect, which may be implemented in conjunction with the thirteenth aspect, the shielding member (VI) suitably has a guide surface (V2) to guide, toward the chip thermistor, a gas flow that has come from the external space (SP2). The fourteenth aspect further reduces the chances of the shielding member (VI) obstructing the influx of heat through the opening (7).

**[0209]** In a sensor (1, 1A-1M) according to a fifteenth aspect, which may be implemented in conjunction with the thirteenth or fourteenth aspect, the housing (5) suitably includes a first cover (such as one of a front cover 51 or a back cover 2) and a second cover (such as the other of the two covers). The first cover covers the board (2) from one side along thickness of the board (2). The second cover covers the board (2) from the other side, opposite from the one side, along the thickness of the board (2). The shielding member (VI) suitably includes: a first projection (V14, V16) protruding from the first cover toward the second cover; and a second projection (V15, V17) protruding from the second cover toward the first cover. The fifteenth aspect may reduce the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while further reducing the chances of the influx of heat through the opening (7) being obstructed.

**[0210]** In a sensor (1, 1A-1M) according to a sixteenth aspect, which may be implemented in conjunction with the fifteenth aspect, the first projection (V14) is suitably arranged as follows. Specifically, when the open area (70) is viewed from the external space (SP2), the first projection (V14) is suitably shifted with respect to the second projection (V15) in a direction perpendicular to an arrangement direction in which the first cover and the

second cover are arranged. The sixteenth aspect further reduces the chances of the shielding member (VI) obstructing the influx of heat through the opening (7).

**[0211]** In a sensor (1, 1A-1M) according to a seventeenth aspect, which may be implemented in conjunction with the fifteenth aspect, the first projection (V16) and the second projection (V17) suitably protrude such that their respective tips face each other. The seventeenth aspect may further reduce the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally.

**[0212]** In a sensor (1, 1A-1M) according to an eighteenth aspect, which may be implemented in conjunction with any one of the fifteenth to seventeenth aspects, at least one (e.g., the second projection V15) of the first projection (V14, V16) or the second projection (V15, V17) is suitably located as follows. Specifically, when the open area (70) is viewed from the external space (SP2), at least one (e.g., the second projection V15) of the first projection (V14, V16) or the second projection (V15, V17) is suitably located at the same position as the chip thermistor in a direction perpendicular to an arrangement direction in which the first cover and the second cover are arranged. In addition, the at least one of the first projection (V14, V16) or the second projection (V15, V17) suitably has a protrusion height thereof defined to expose the chip thermistor at least partially when the open area (70) is viewed from the external space (SP2). The eighteenth aspect may reduce the chances of a human finger or a tool, for example, coming into contact with the chip thermistor accidentally while further reducing the chances of the influx of heat through the opening (7) being obstructed.

**[0213]** In a sensor (1, 1A-1M) according to a nineteenth aspect, which may be implemented in conjunction with any one of the first to eighteenth aspects, the opening (7) suitably includes an inlet port (7B). The inlet port (7B) is provided through an outer surface (53) of the housing (5). The outer surface (53) is located opposite from a structural component (XI) on which the sensor (1, 1A-1M) is to be mounted. The nineteenth aspect allows the heat of the gas that has flowed in through the inlet port (7B) to be detected, thus improving the responsivity to heat detection.

**[0214]** In a sensor (1, 1A-1M) according to a twentieth aspect, which may be implemented in conjunction with the nineteenth aspect, the outer surface (53) suitably includes: a first surface (531) provided to surround the inlet port (7B); and a second surface (532) provided outside of the first surface (531). The first surface (531) is suitably formed in a shape of a taper that is sloped, at a different tilt angle from the second surface (532), toward the structural component (XI) as a distance to the inlet port (7B) decreases. The twentieth aspect allows the influx of heat toward the inlet port (7B) to be further accelerated.

**[0215]** In a sensor (1, 1A-1M) according to a twenty-first aspect, which may be implemented in conjunction with any one of the first to twentieth aspects, the housing

(5) suitably includes a single or a plurality of projections (W1). The single or plurality of projections (W1) protrude from an edge portion of the opening (7) in a direction pointing away from a structural component (XI) on which the sensor (1, 1A-1M) is to be mounted. The single or plurality of projections (W1) are suitably configured to come, when a tester (900) is positioned to cover the housing (5), into contact with a peripheral edge portion (901) of the tester (900). The tester (90) is used to conduct a heating test on the heat sensitive element (30). According to the twenty-first aspect, providing the projection (W1) allows the tester (900) to be positioned with good stability with respect to the housing (5). That is to say, this increases the chances of the projection (W1) making a point contact with the peripheral edge portion (901), thus reducing backlash compared to a situation where these portions make a plane contact with each other.

**[0216]** Note that constituent elements according to the second to twenty-first aspects are not essential constituent elements for the sensor (1, 1A-1M) but may be omitted as appropriate.

#### Reference Signs List

##### [0217]

1, 1A-1M	Sensor
2	Board
30	Heat Sensitive Element
4	Smoke Detection Unit
41	Optical Element
42	Photosensitive Element
43	Labyrinth Structure
5	Housing
51	Front Cover (Second Cover)
52	Back Cover (First Cover)
53	Outer Surface
531	First Surface
532	Second Surface
55	Installation Surface
522	Control Plate (Wall Member)
6	Flow Channel
61	First Channel
62	Second Channel
7	Opening
7B	Inlet Port
70	Open Area
P1	Middle
SP1	Internal Space
SP2	External space
V1	Shielding Member
V14, V16	First Projection
V15, V17	Second Projection
V2	Guide Surface
W1	Projection
X1	Structural Component
900	Tester
901	Peripheral Edge Portion

**Claims**

1. A sensor comprising:
- a board;
- a heat sensitive element; and
- a housing to house the board,
- the housing having:
- a flow channel provided in an internal space thereof and configured to allow a gas to flow therethrough; and
- an opening connecting the flow channel to an external space outside of the housing,
- the heat sensitive element being implemented as a chip thermistor mounted on the board and configured to detect heat of the gas that has flowed in through the opening.
2. The sensor of claim 1, wherein a surface of the board is exposed at least partially to the flow channel.
3. The sensor of claim 1 or 2, wherein the chip thermistor is arranged, when an open area of the opening is viewed from the external space, to fall within the open area.
4. The sensor of claim 3, wherein when the open area is viewed from the external space, the chip thermistor is located, inside the open area, at a middle of the open area in a direction perpendicular to the surface of the board.
5. The sensor of any one of claims 1 to 4, wherein the flow channel includes: a first channel located closer to the opening; and a second channel connected to the first channel and located closer to a central area of the internal space, and the chip thermistor is provided in the first channel.
6. The sensor of any one of claims 1 to 5, wherein the flow channel includes: a first channel located closer to the opening; and a second channel connected to the first channel and located closer to a central area of the internal space, and the first channel has a smaller open cross-sectional area than the second channel.
7. The sensor of claim 6, wherein the housing has an installation surface configured to face a structural component on which the sensor is to be mounted, and the second channel expands toward the installation surface as a distance, measured in a direction pointing from the first channel toward the central area, decreases.
8. The sensor of any one of claims 1 to 7, further comprising a smoke detection unit arranged in the central area of the internal space and configured to detect smoke.
9. The sensor of claim 8, wherein the smoke detection unit is arranged on the same side as a surface of the board on which the chip thermistor is mounted.
10. The sensor of claim 8 or 9, wherein the housing has an installation surface configured to face a structural component on which the sensor is to be mounted, and the smoke detection unit is arranged on one surface selected from the group consisting of two surfaces that are a surface of the board and a back surface thereof opposite from the surface, the one surface being located closer to the installation surface than the other of the two surfaces is.
11. The sensor of any one of claims 8 to 10, wherein the housing includes, inside the internal space, a single or a plurality of wall members configured to guide the gas toward either the heat sensitive element or the smoke detection unit.
12. The sensor of any one of claims 8 to 11, wherein the housing has an installation surface configured to face a structural component on which the sensor is to be mounted, the smoke detection unit includes:
- an optical element configured to emit light;
- a photosensitive element configured to receive the light emitted from the optical element; and
- a labyrinth structure in which the optical element and the photosensitive element are arranged to avoid facing each other, and
- when measured along thickness of the board, a middle of an internal space of the labyrinth structure is located between the chip thermistor and the installation surface.
13. The sensor of any one of claims 1 to 12, wherein the chip thermistor is arranged, when an open area of the opening is viewed from the external space, to fall within the open area, and the sensor further includes a shielding member provided closer to the external space than the chip thermistor is and configured to partially shut off the open area.
14. The sensor of claim 13, wherein the shielding member has a guide surface configured to guide, toward the chip thermistor, a gas flow that has come from the external space.

15. The sensor of claim 13 or 14, wherein the housing includes:
- a first cover covering the board from one side along thickness of the board; and 5
  - a second cover covering the board from the other side, opposite from the one side, along the thickness of the board, and
- the shielding member includes: 10
- a first projection protruding from the first cover toward the second cover; and
  - a second projection protruding from the second cover toward the first cover. 15
16. The sensor of claim 15, wherein the first projection is arranged to be shifted, when the open area is viewed from the external space, with respect to the second projection in a direction perpendicular to an arrangement direction in which the first cover and the second cover are arranged. 20
17. The sensor of claim 15, wherein the first projection and the second projection protrude such that their respective tips face each other. 25
18. The sensor of any one of claims 15 to 17, wherein when the open area is viewed from the external space, at least one of the first projection or the second projection is located at the same position as the chip thermistor in a direction perpendicular to an arrangement direction in which the first cover and the second cover are arranged, and the at least one of the first projection or the second projection has a protrusion height thereof defined to expose the chip thermistor at least partially. 30 35
19. The sensor of any one of claims 1 to 18, wherein the opening includes an inlet port, and the inlet port is provided through an outer surface of the housing, the outer surface being located opposite from a structural component on which the sensor is to be mounted. 40 45
20. The sensor of claim 19, wherein the outer surface includes: a first surface provided to surround the inlet port; and a second surface provided outside of the first surface, and the first surface is formed in a shape of a taper that is sloped, at a different tilt angle from the second surface, toward the structural component as a distance to the inlet port decreases. 50
21. The sensor of any one of claims 1 to 20, wherein the housing includes a single or a plurality of projections that protrude from an edge portion of the opening in a direction pointing away from a structural com- 55
- ponent on which the sensor is to be mounted, and the single or plurality of projections are configured to come, when a tester is positioned to cover the housing, into contact with a peripheral edge portion of the tester, the tester being configured to conduct a heating test on the heat sensitive element.

FIG. 1

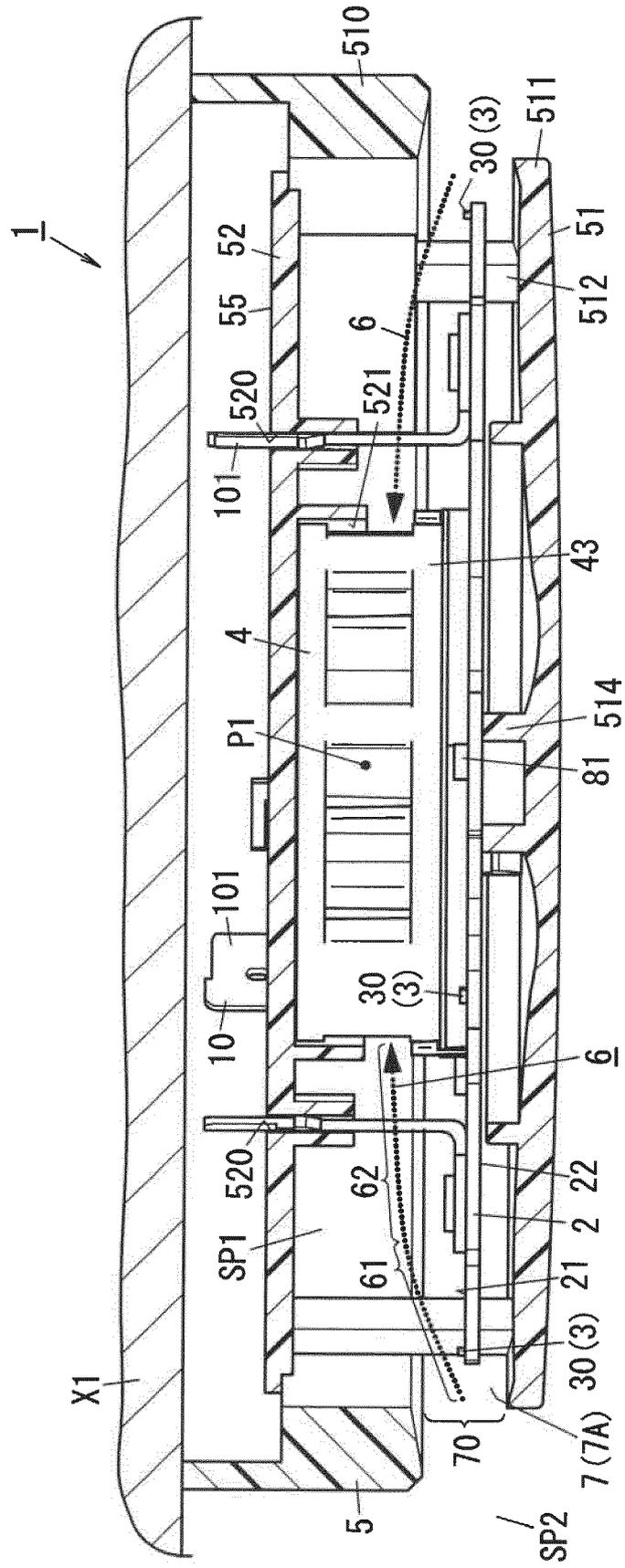


FIG. 2

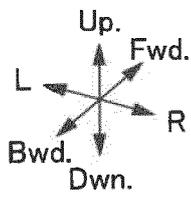
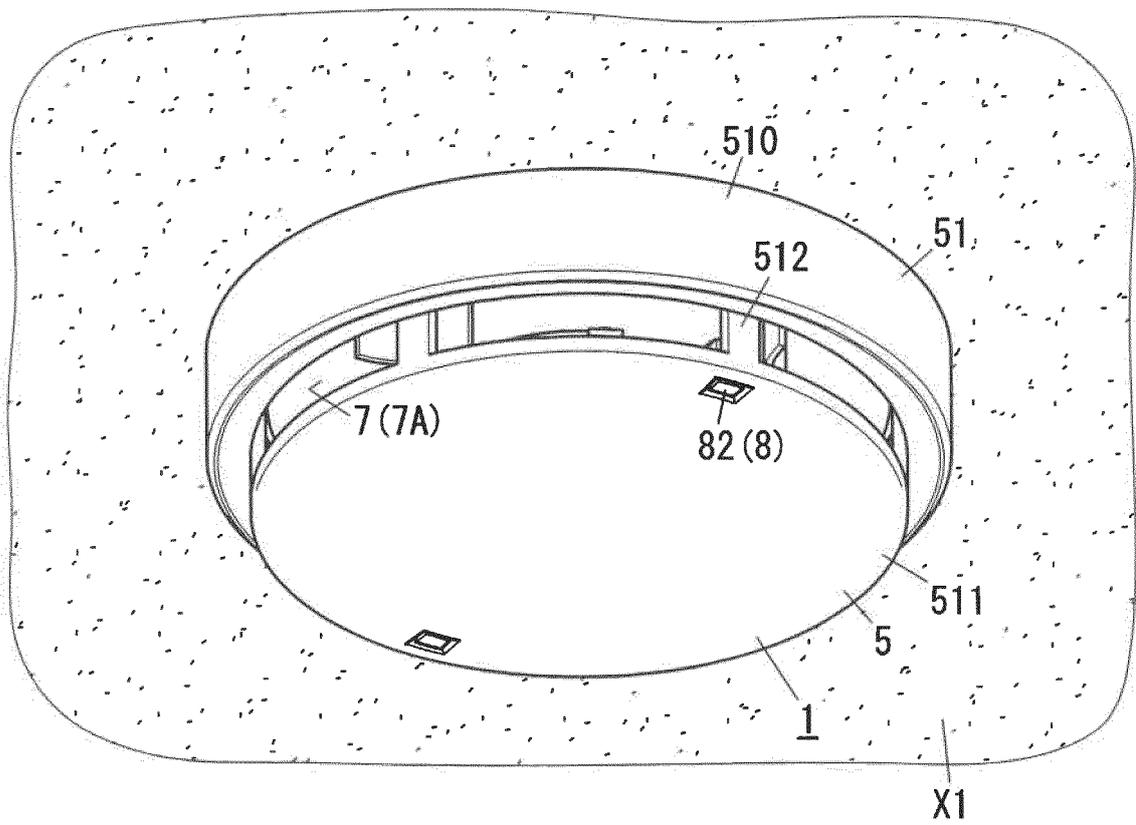


FIG. 3A

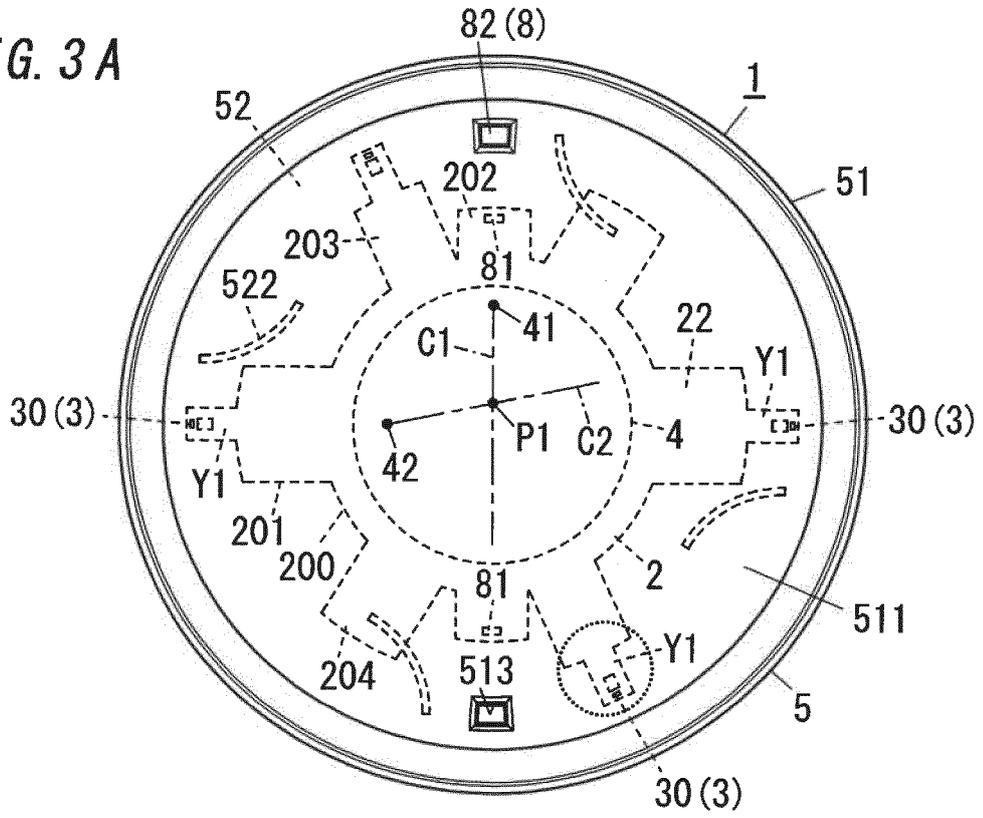


FIG. 3B

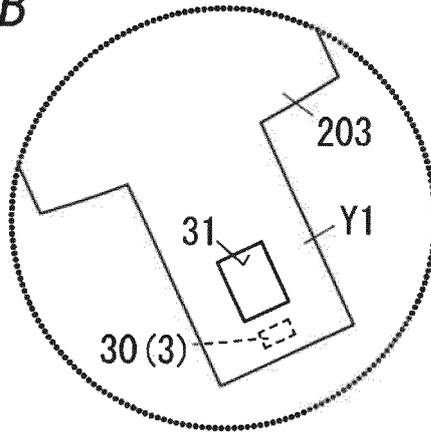


FIG. 4

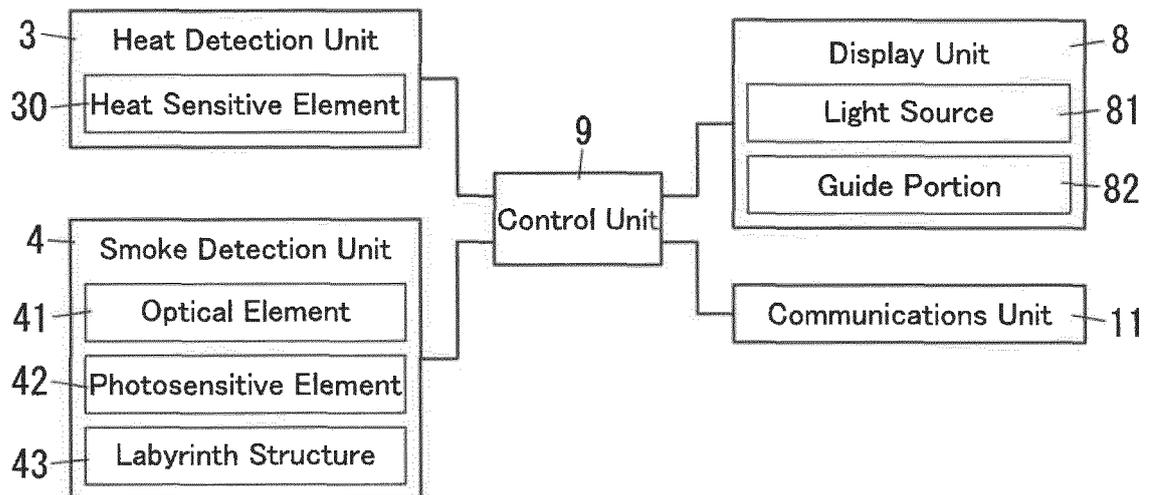


FIG. 5

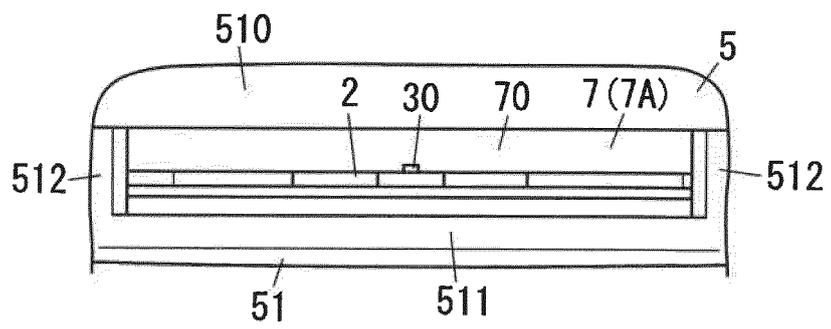




FIG. 7

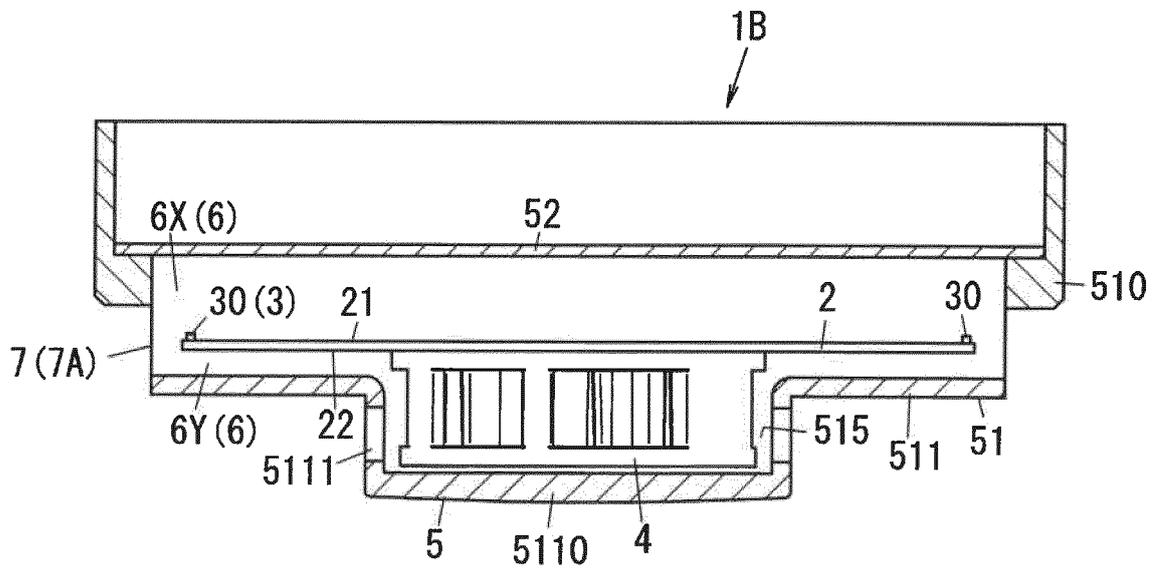


FIG. 8A

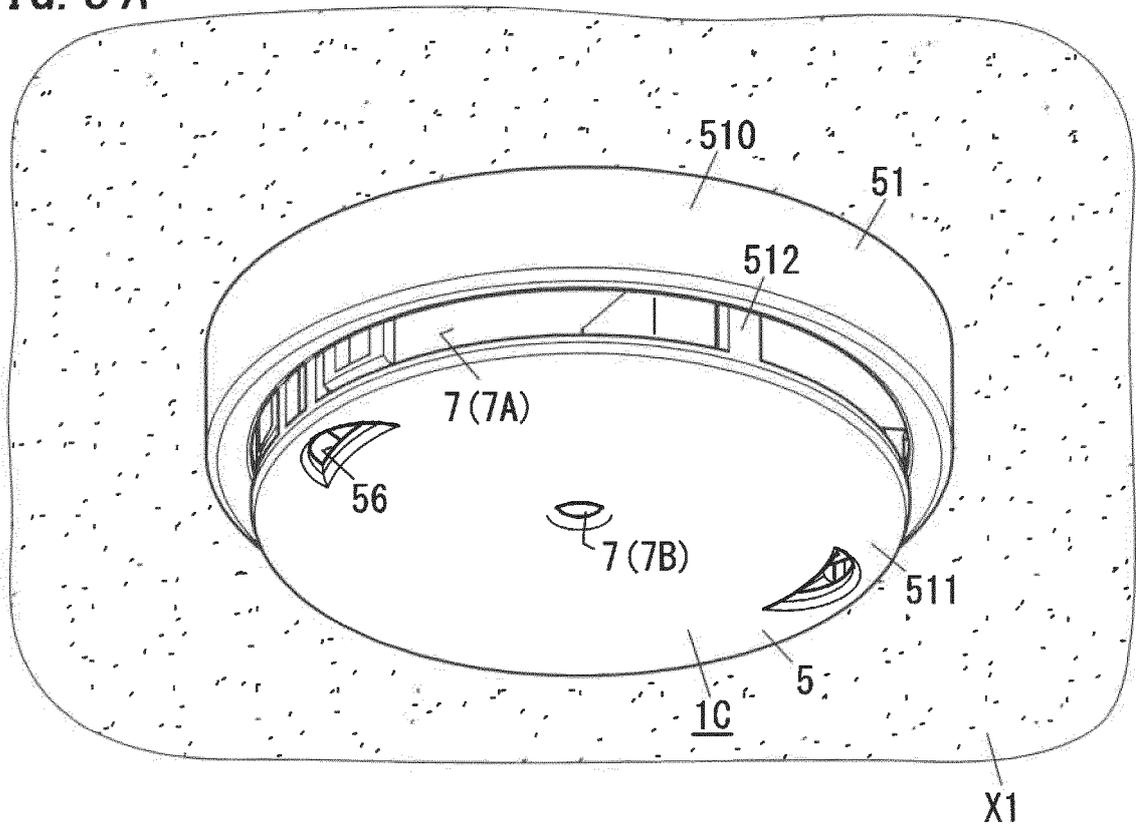


FIG. 8B

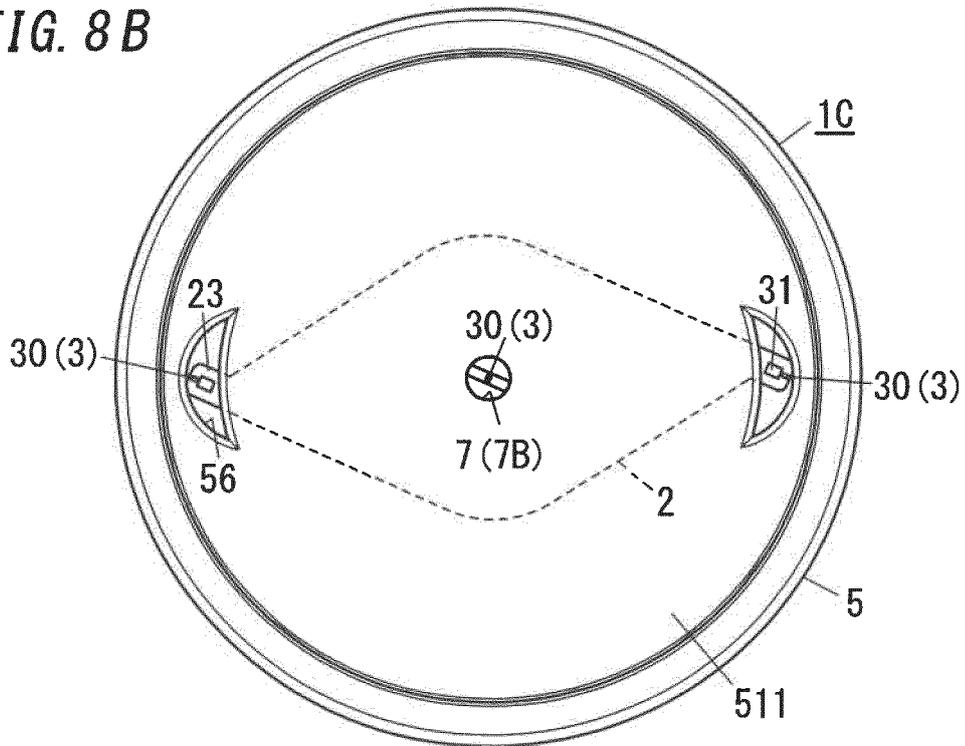


FIG. 9A

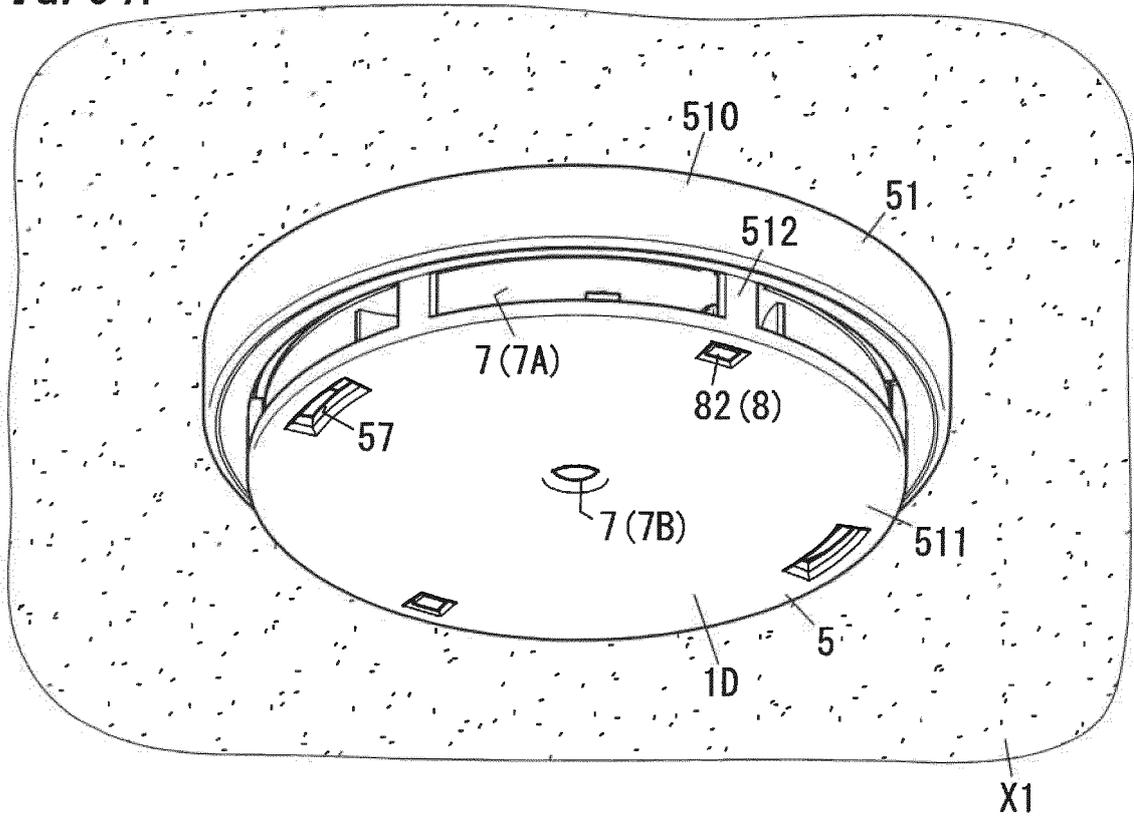


FIG. 9B

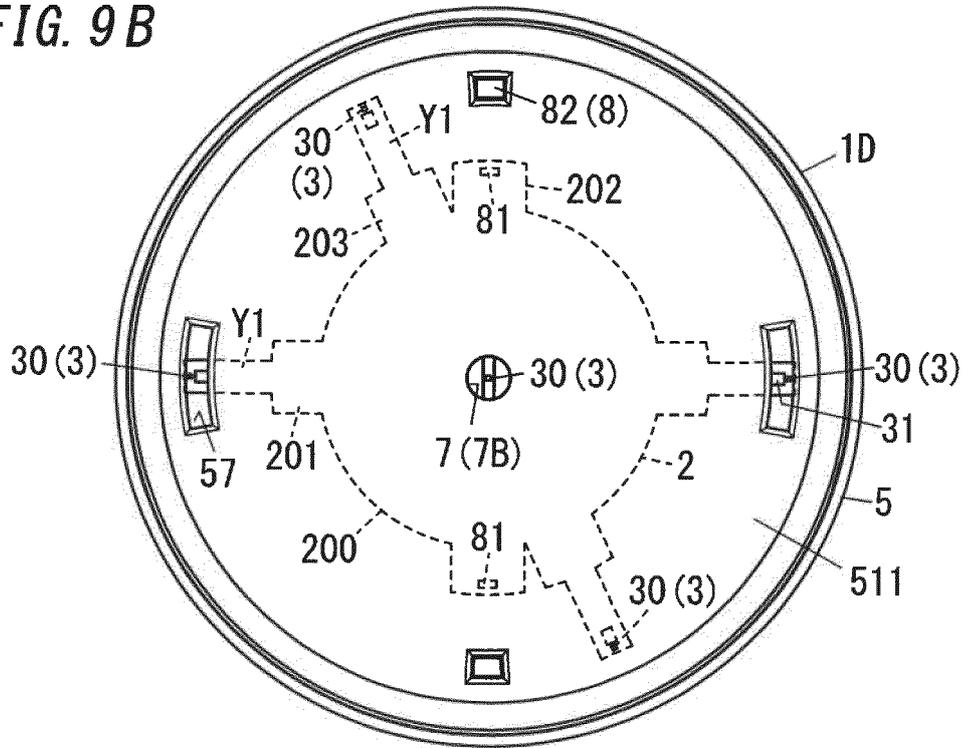


FIG. 10A

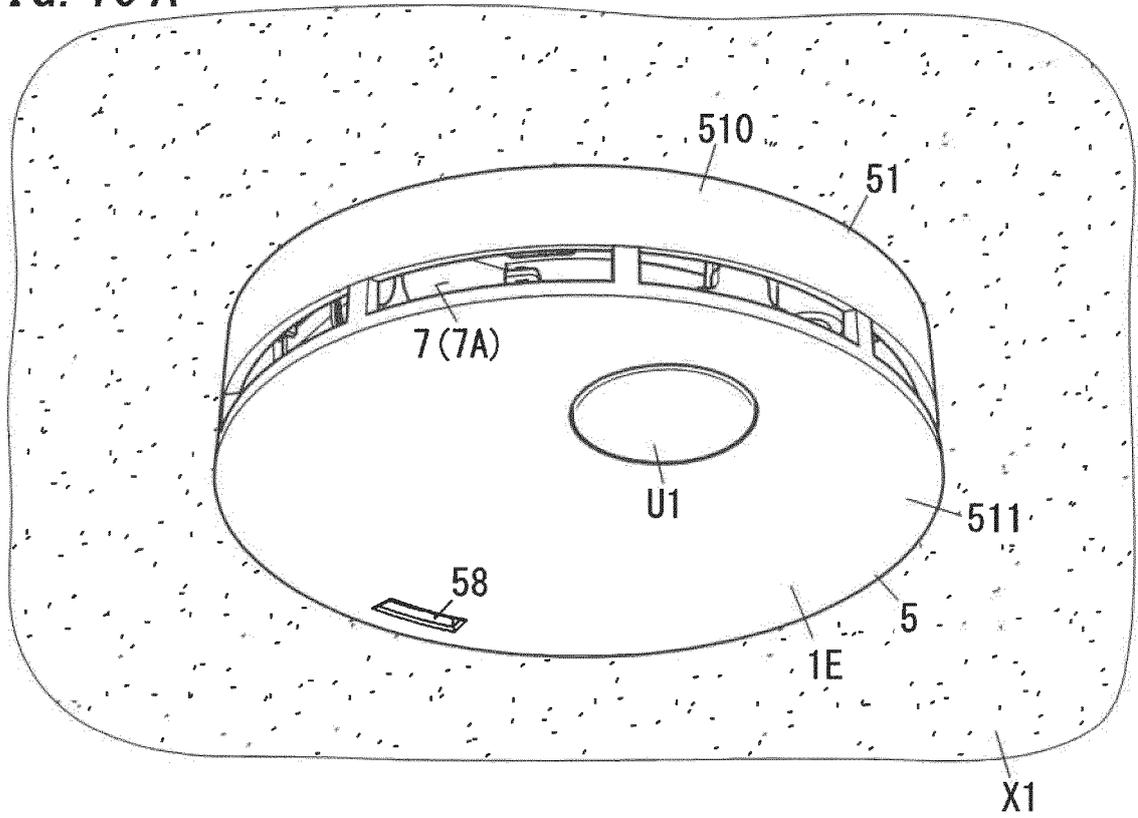


FIG. 10B

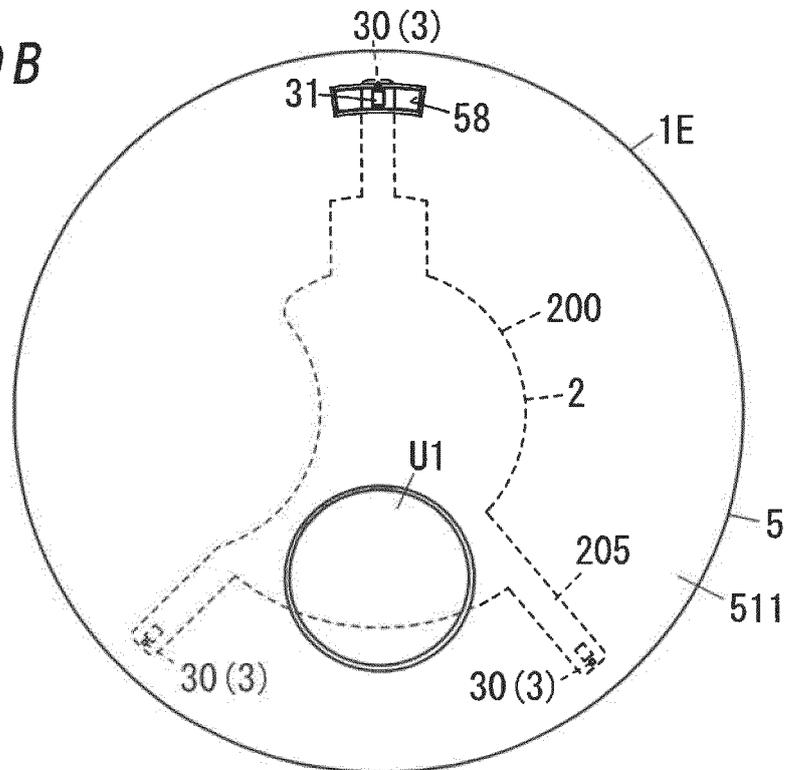


FIG. 11

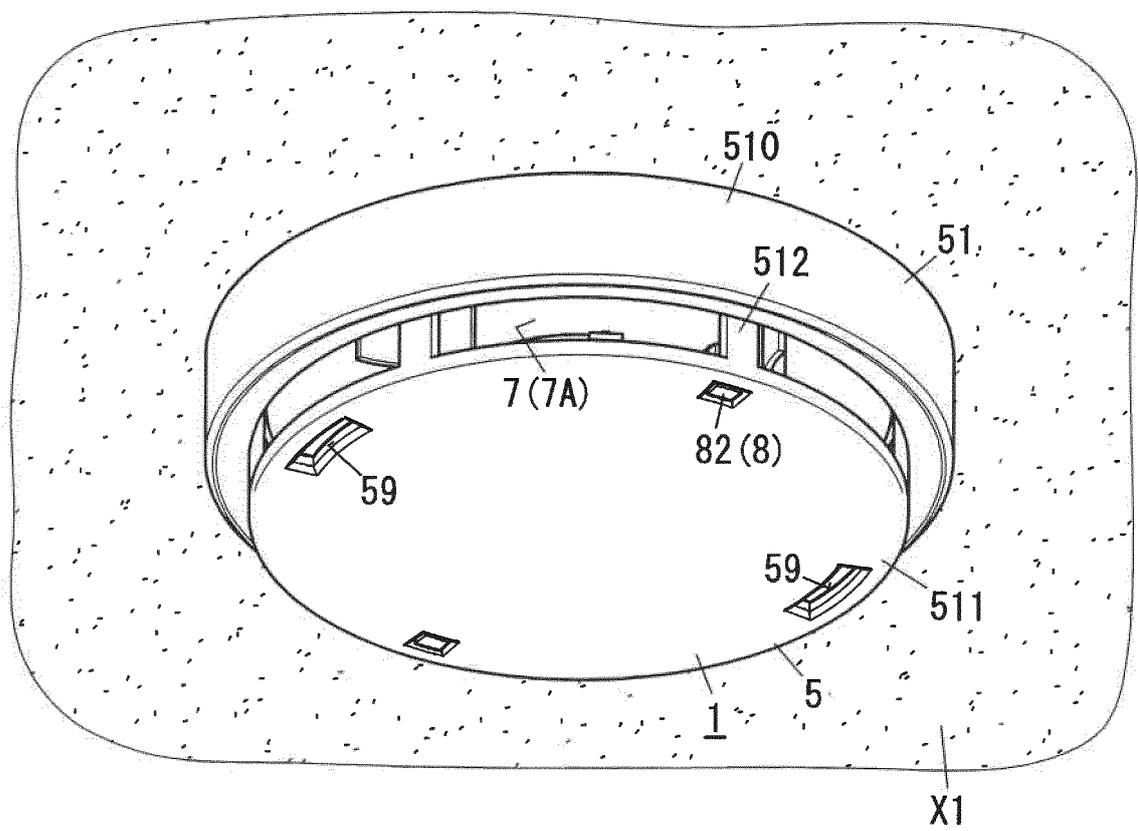


FIG. 12 A

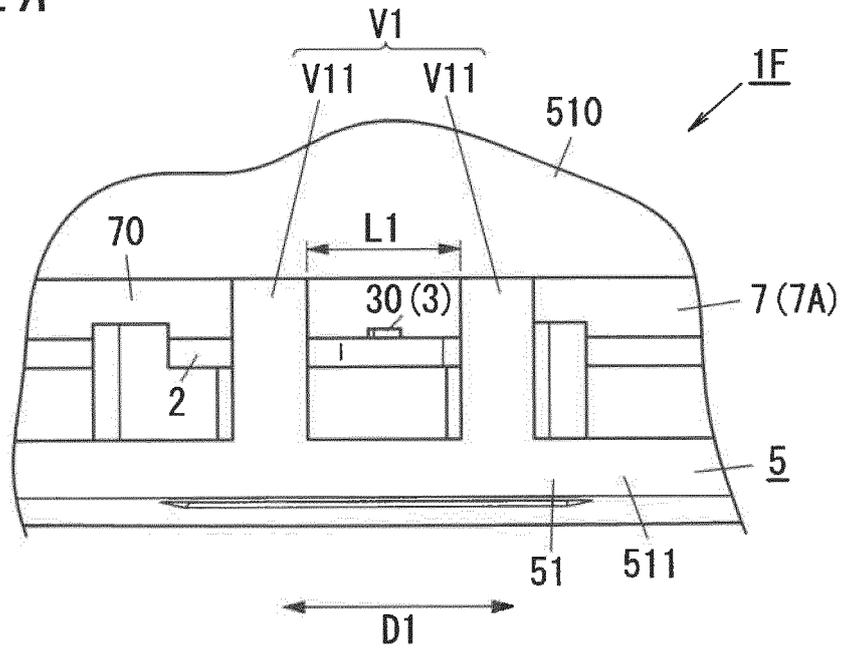


FIG. 12 B

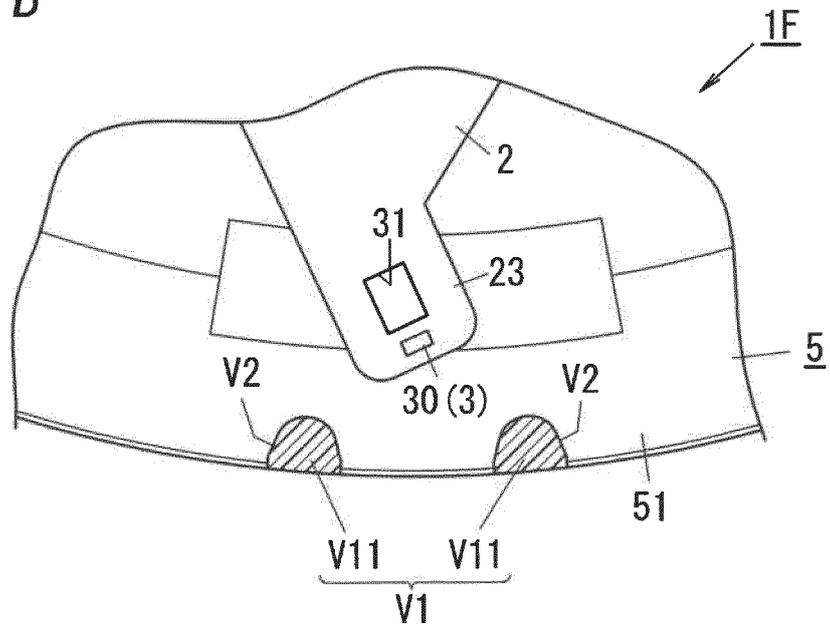


FIG. 13A

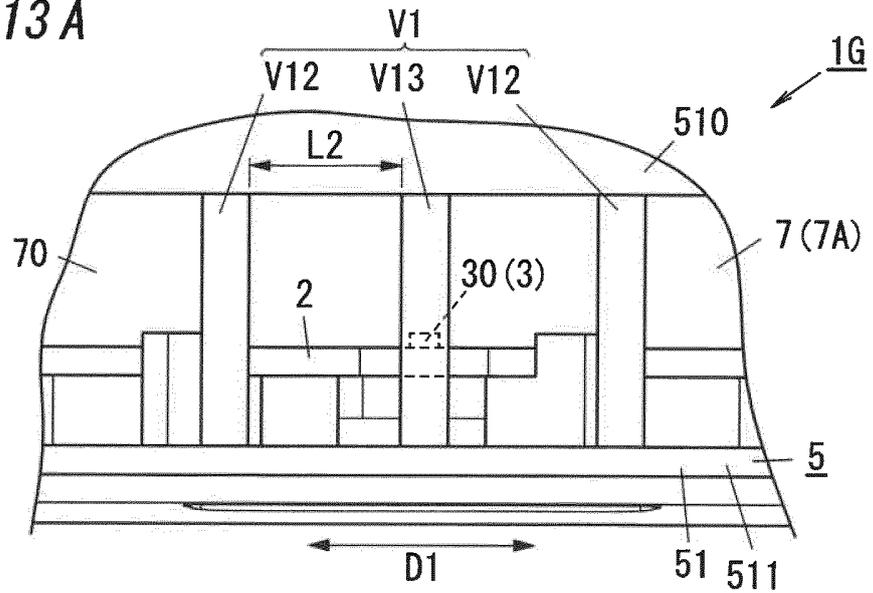


FIG. 13B

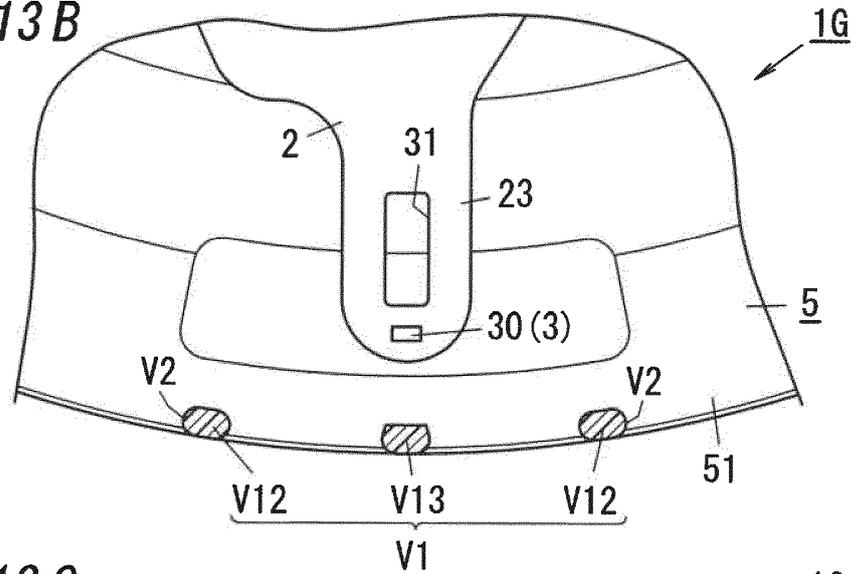


FIG. 13C

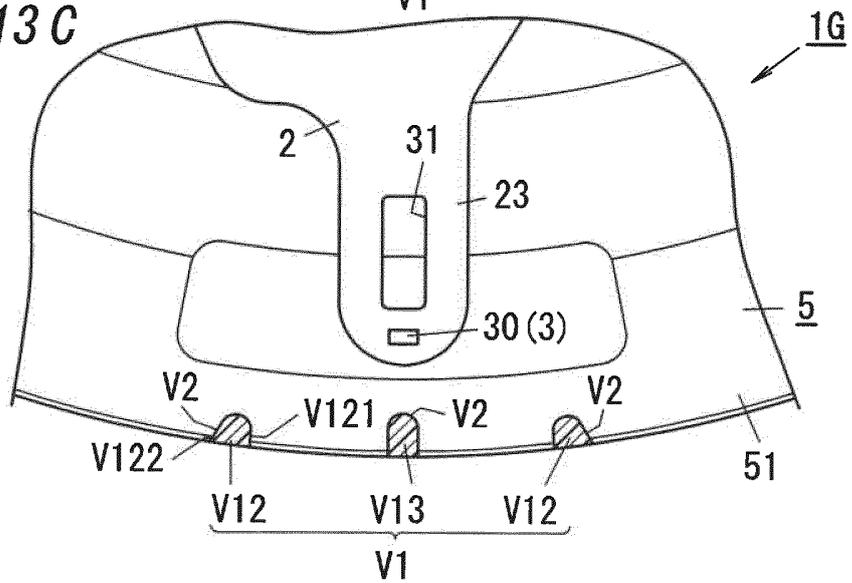


FIG. 14A

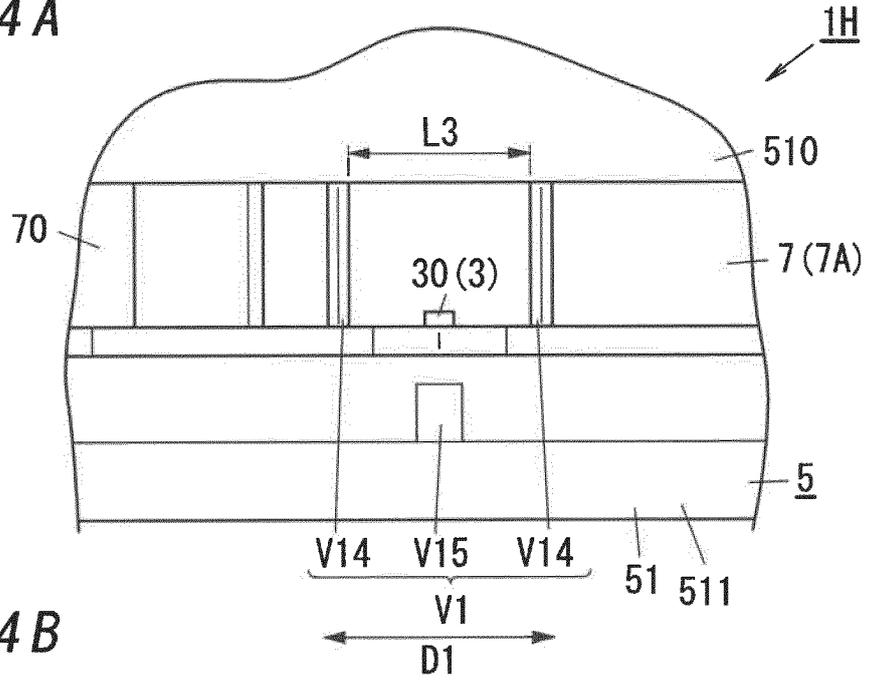


FIG. 14B

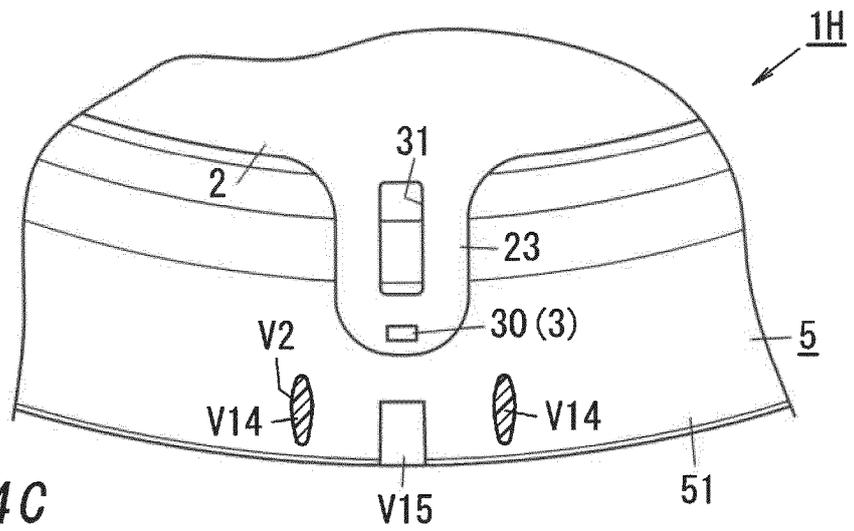


FIG. 14C

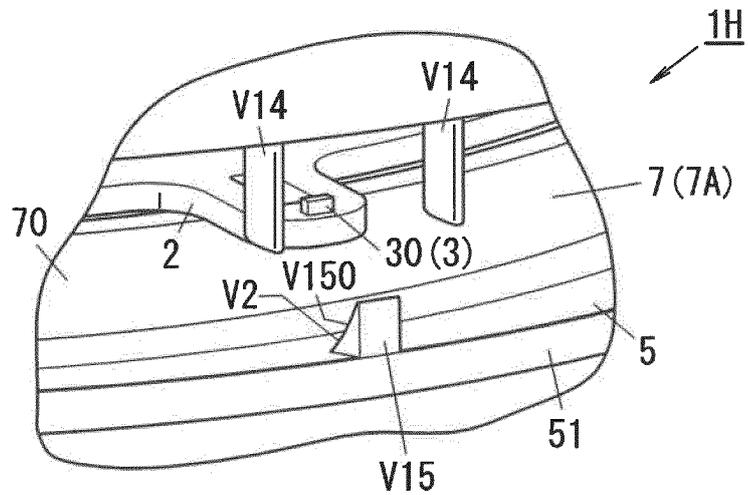


FIG. 15

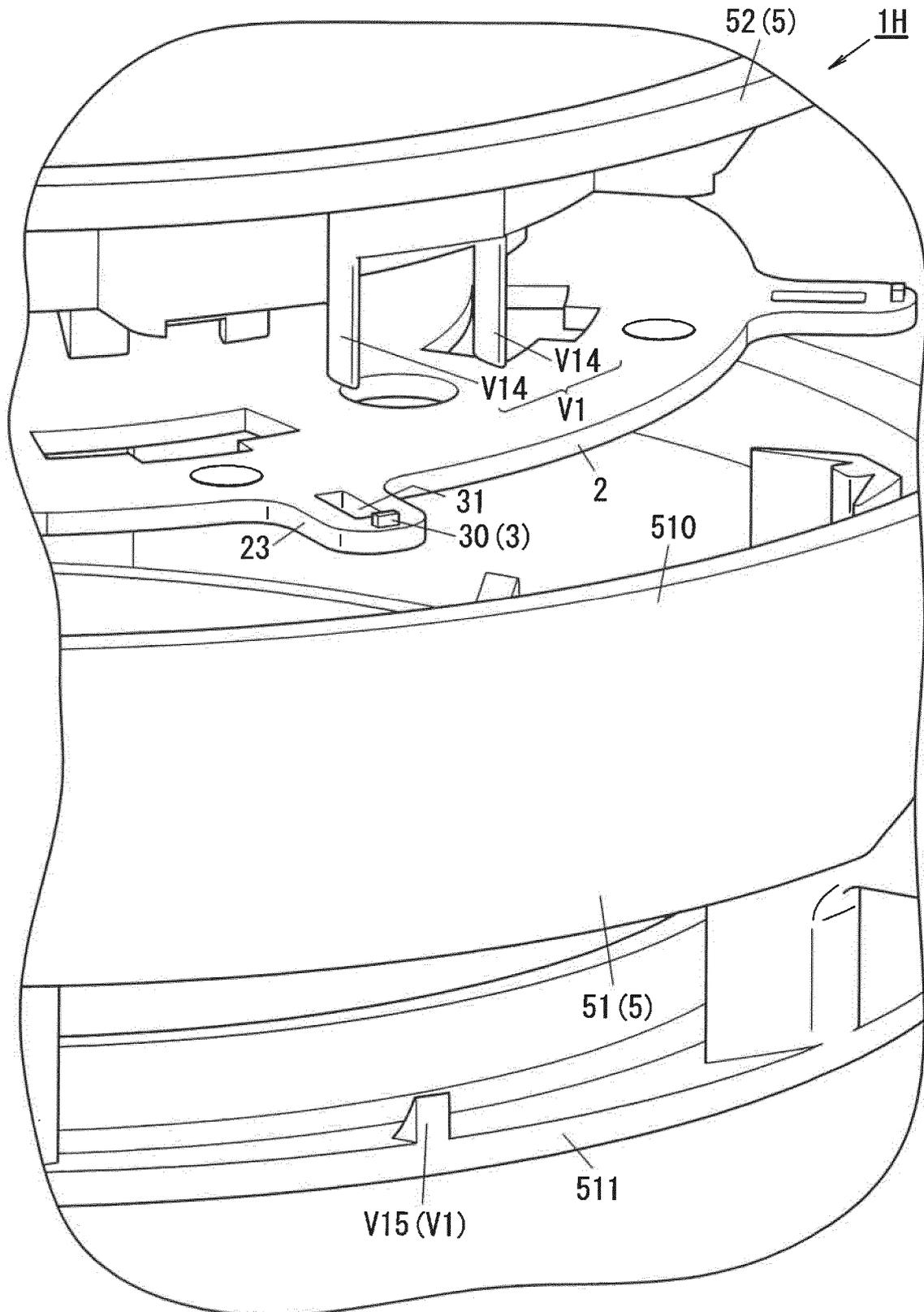
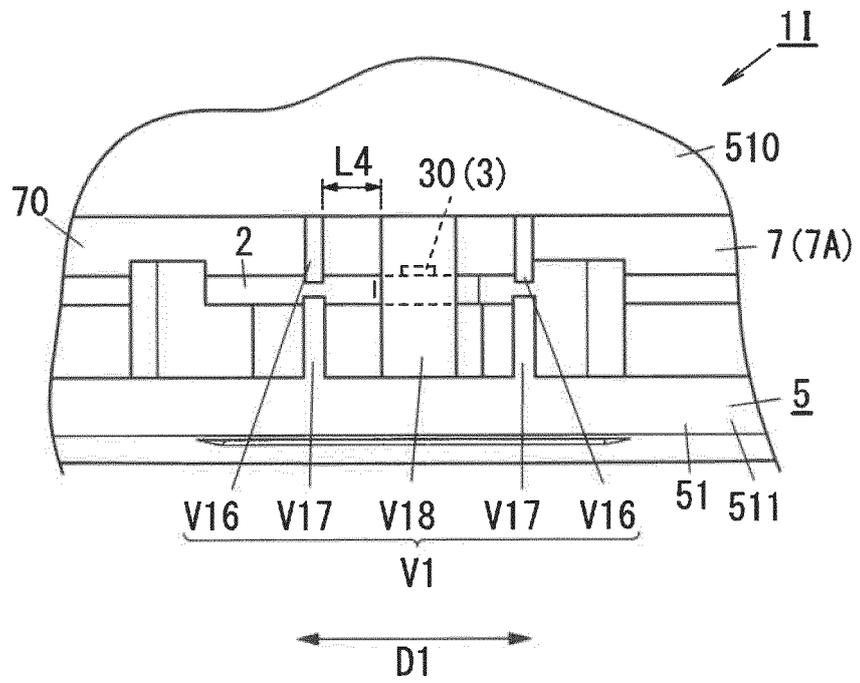
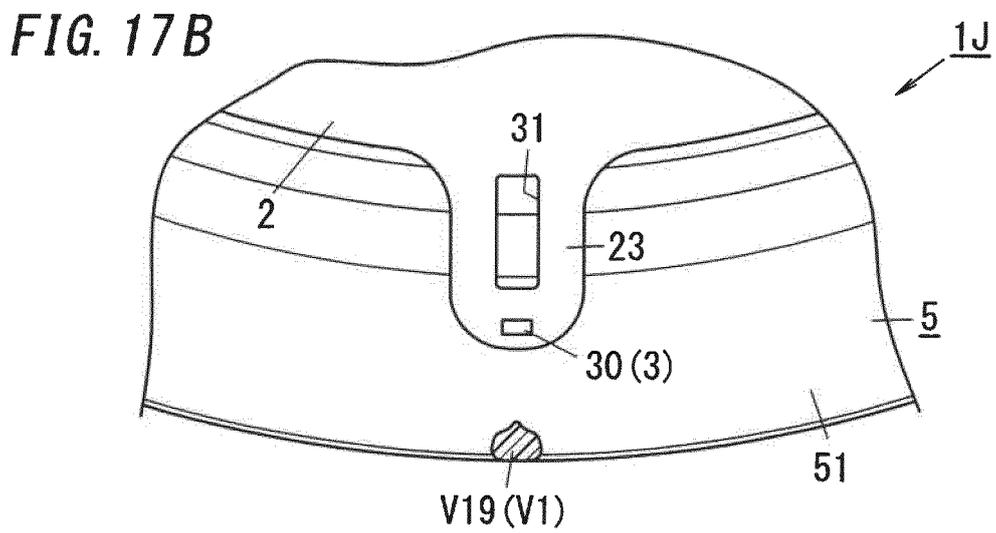
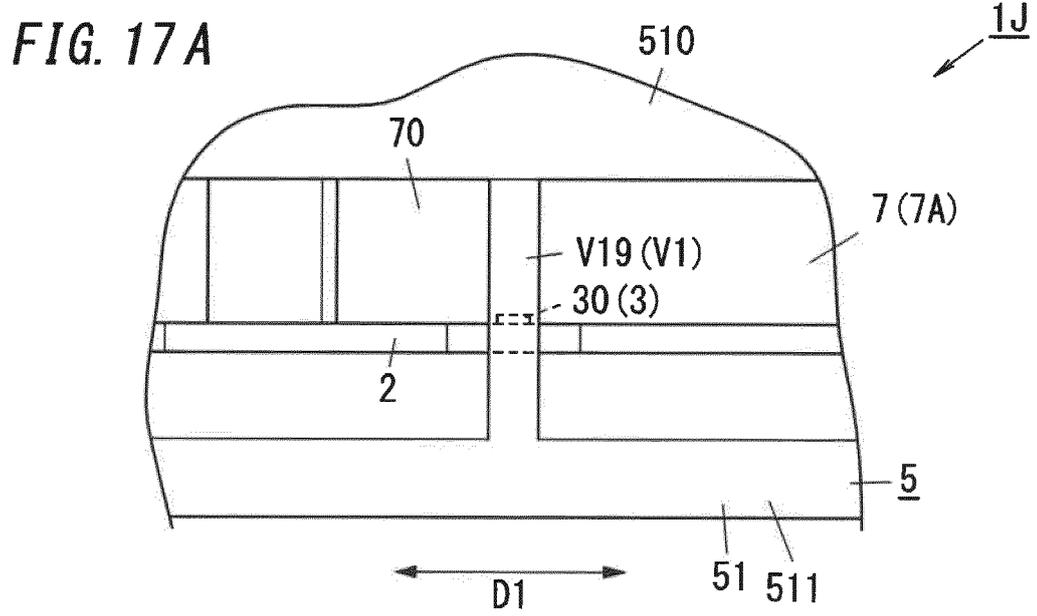


FIG. 16





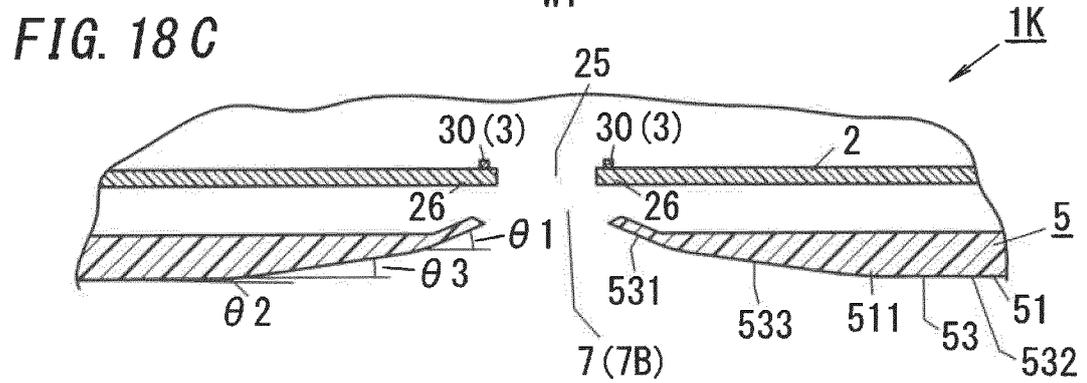
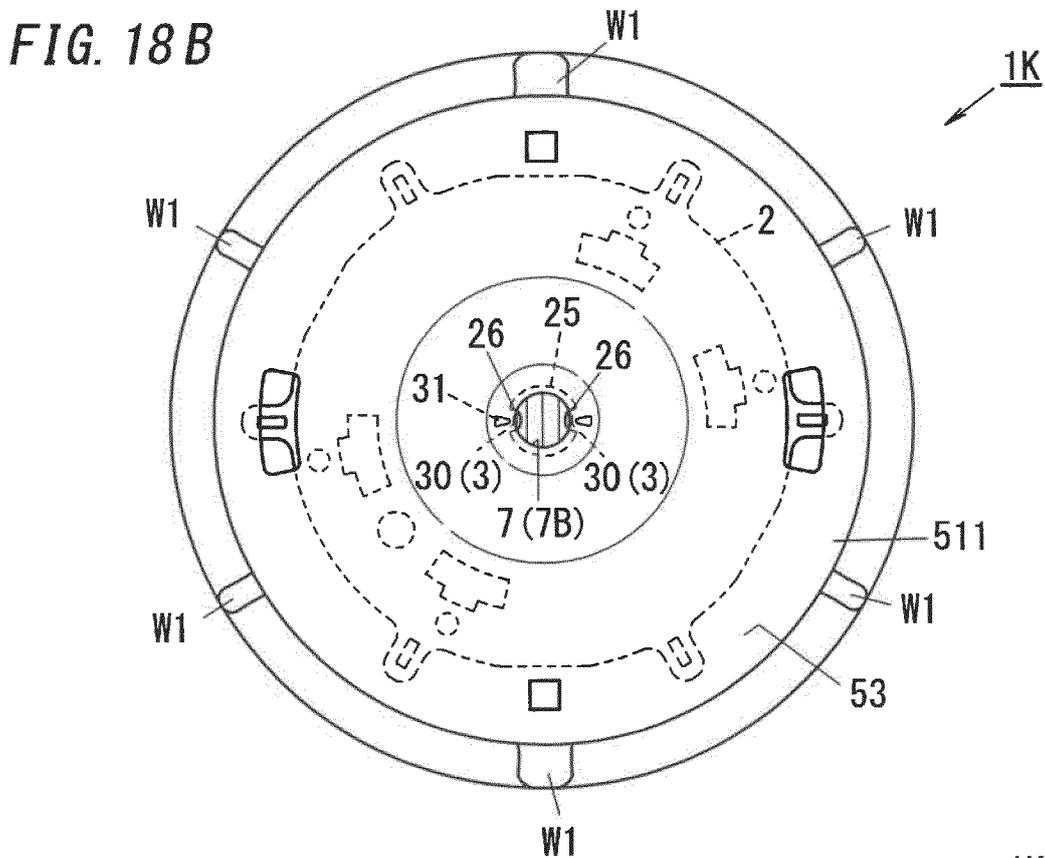
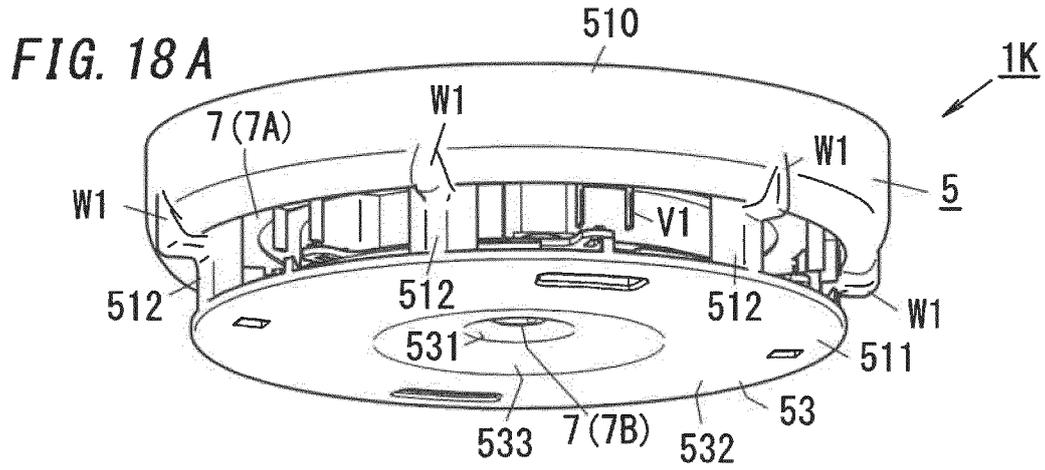


FIG. 19B

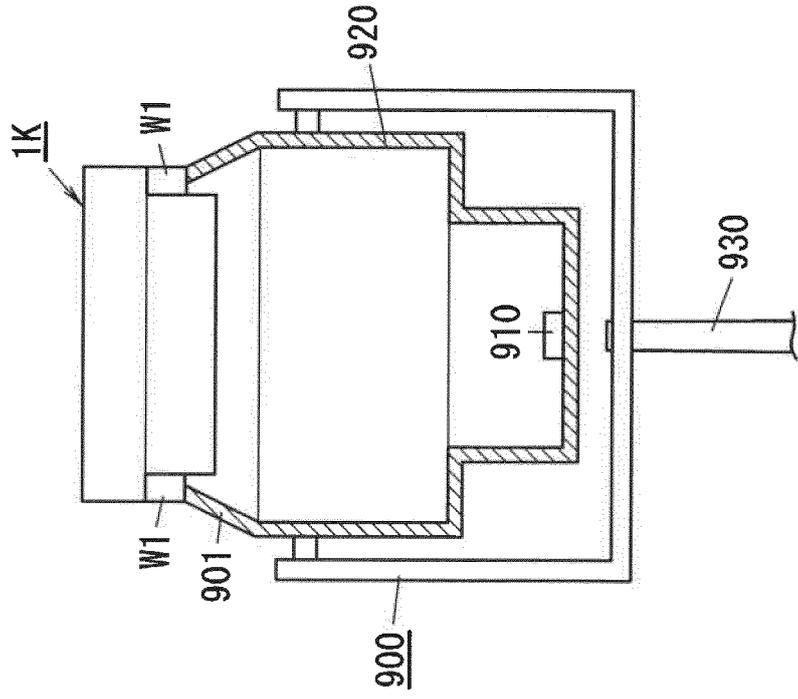


FIG. 19A

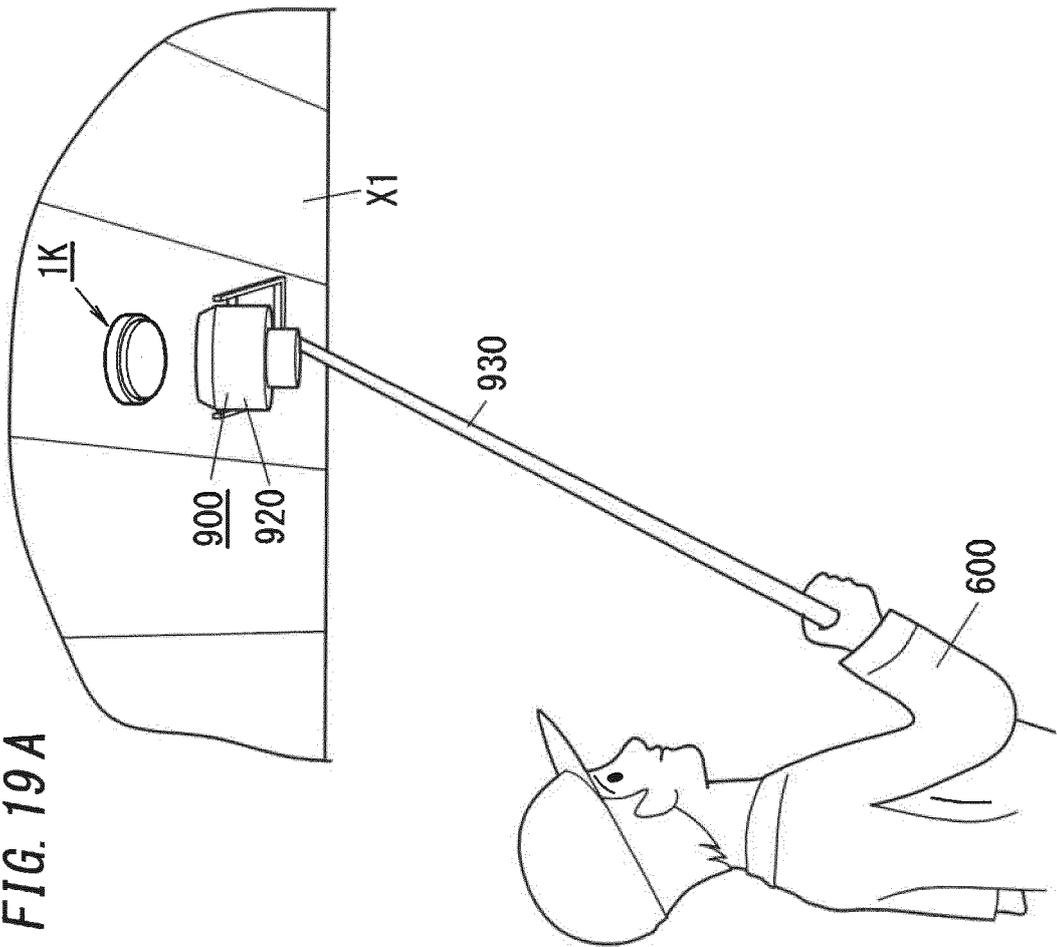


FIG. 20

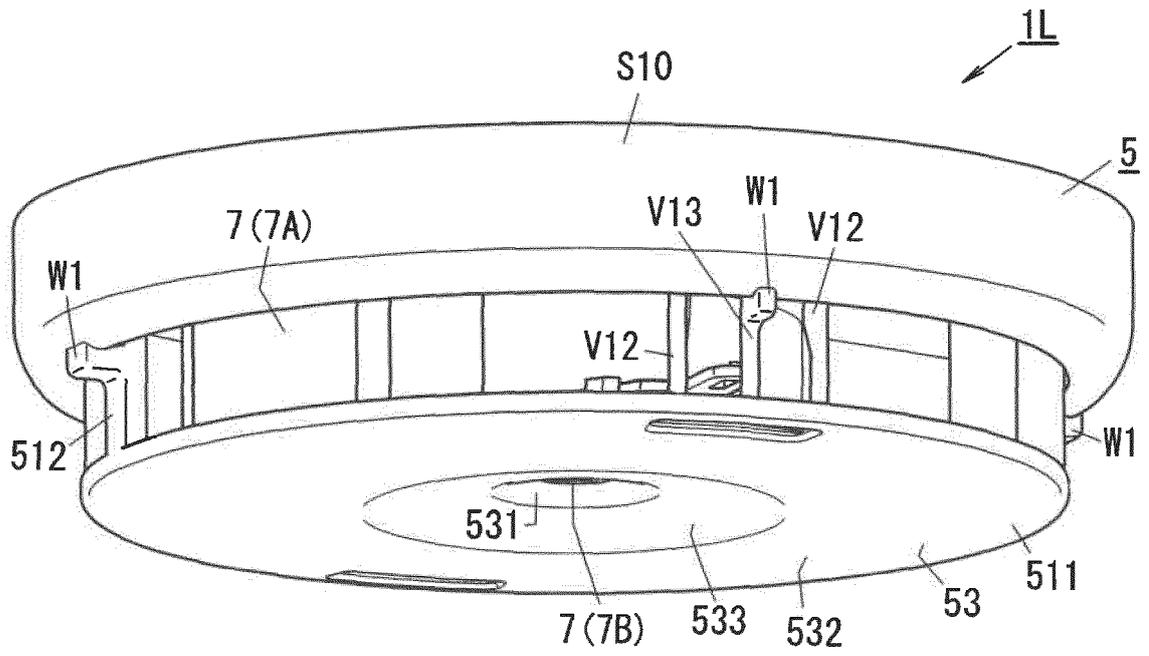


FIG. 21 A

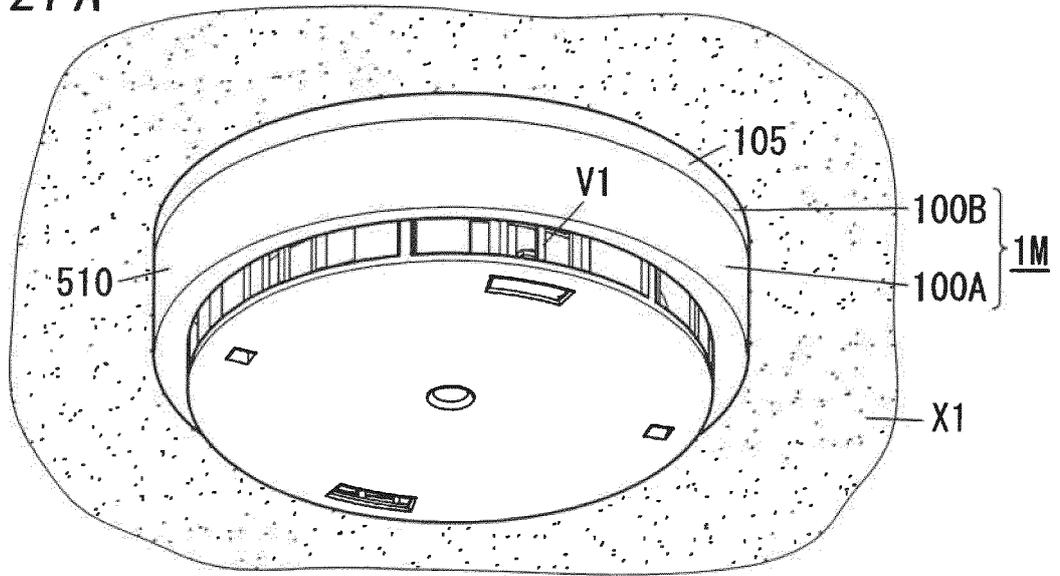


FIG. 21 B

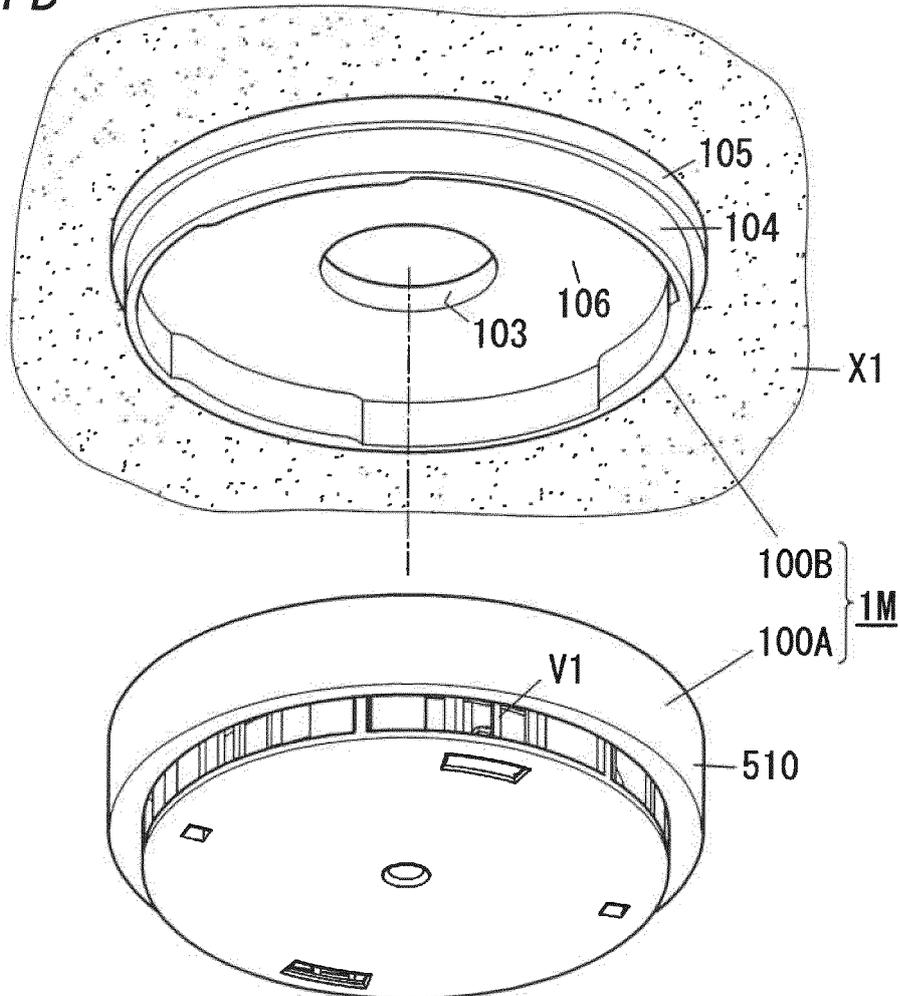


FIG. 22 A

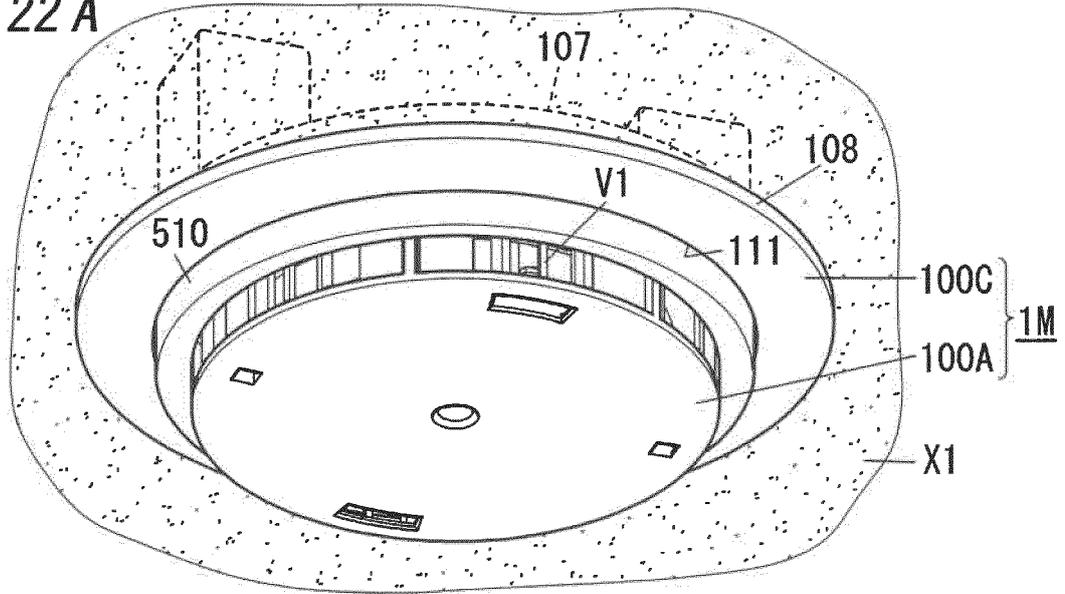


FIG. 22 B

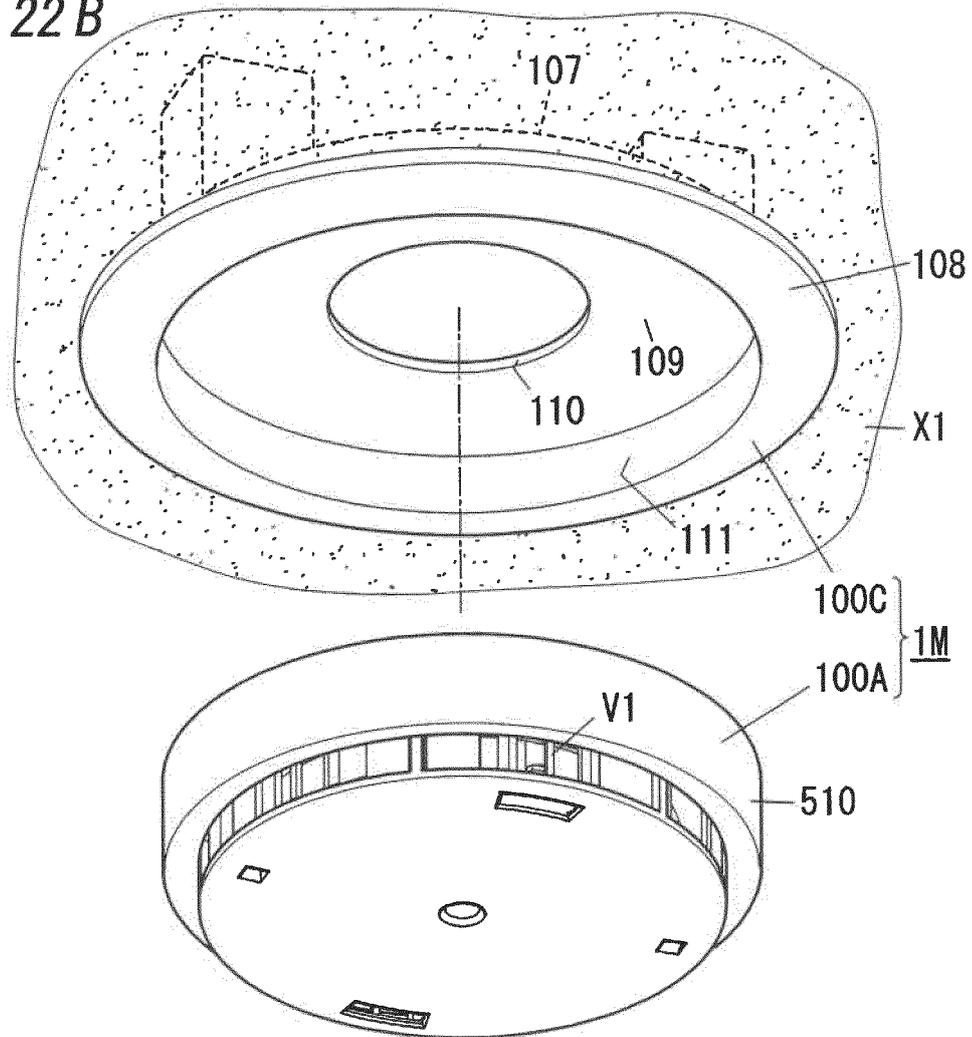


FIG. 23A

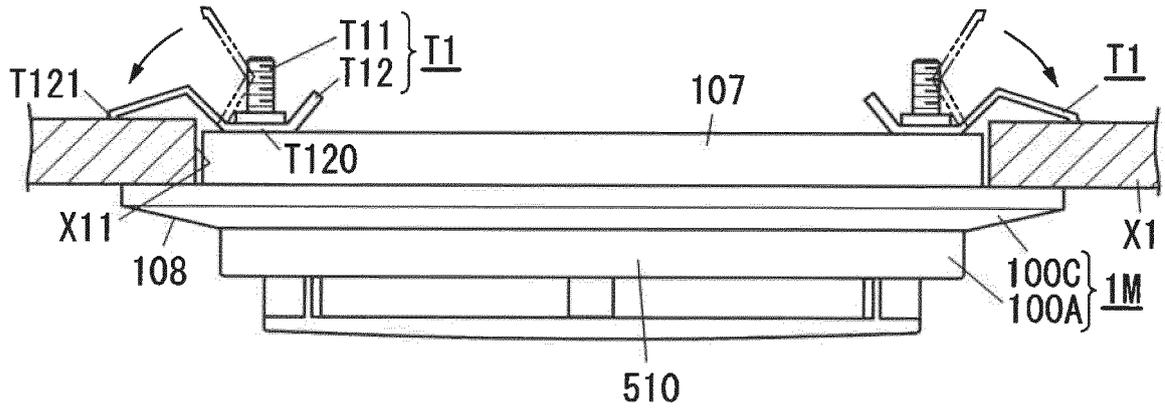
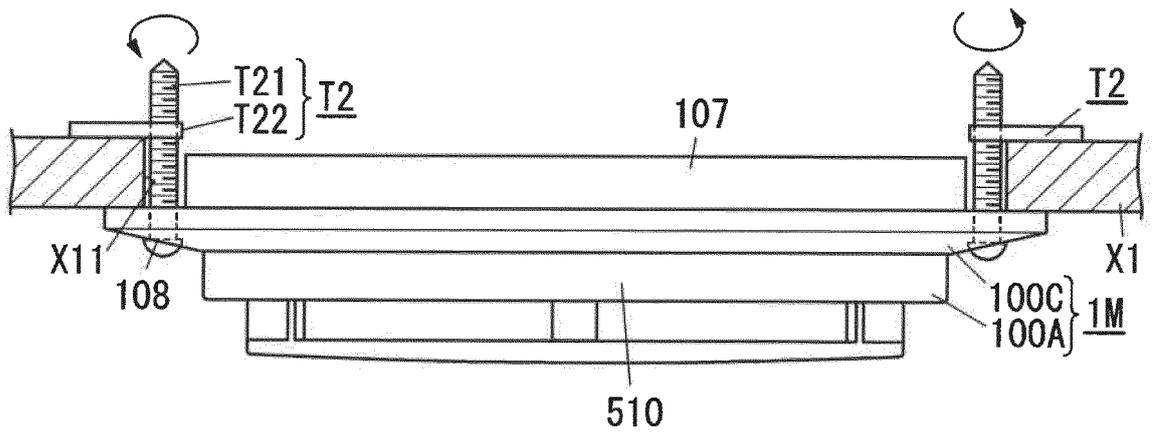


FIG. 23B



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/037270

## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. G08B17/06 (2006.01) i, G08B17/00 (2006.01) i, G08B17/103 (2006.01) i

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. G08B17/06, G08B17/00, G08B17/103

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 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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 2005-71139 A (MATSUSHITA ELECTRIC WORKS, LTD.)	1-4
Y	17 March 2005, paragraphs [0023]-[0029]	1-3, 5-12, 19-21
A	(Family: none)	13-18
Y	JP 2014-126878 A (HOCHIKI CORP.) 07 July 2014, paragraphs [0062]-[0067]	1-3, 5-12, 19-21
A	(Family: none)	13-18

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

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Date of the actual completion of the international search  
06.11.2019Date of mailing of the international search report  
19.11.2019Name and mailing address of the ISA/  
Japan Patent Office  
3-4-3, Kasumigaseki, Chiyoda-ku,  
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/037270

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-230510 A (PANASONIC ELECTRIC WORKS CO., LTD.) 08 October 2009, paragraph [0035], fig. 8 (Family: none)	5, 10, 12
Y	JP 2010-117881 A (FENWALL CONTROLS OF JAPAN LTD.) 27 May 2010, paragraph [0030], fig. 8 (Family: none)	6-7, 19-20
Y	JP 2011-215689 A (NOHMI BOSAI LTD.) 27 October 2011, fig. 4, 8-11 (Family: none)	6-7
Y	JP 9-16869 A (MATSUSHITA ELECTRIC WORKS, LTD.) 17 January 1997, paragraphs [0017]-[0022] (Family: none)	8-12, 19-20
Y	JP 2009-245088 A (NOHMI BOSAI LTD.) 22 October 2009, paragraphs [0012]-[0028] (Family: none)	8-12
Y	JP 2005-250912 A (NOHMI BOSAI LTD.) 15 September 2005, paragraphs [0022]-[0024], [0029] (Family: none)	21

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2012014330 A [0004]