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(54) Title: LEAK DETECTOR

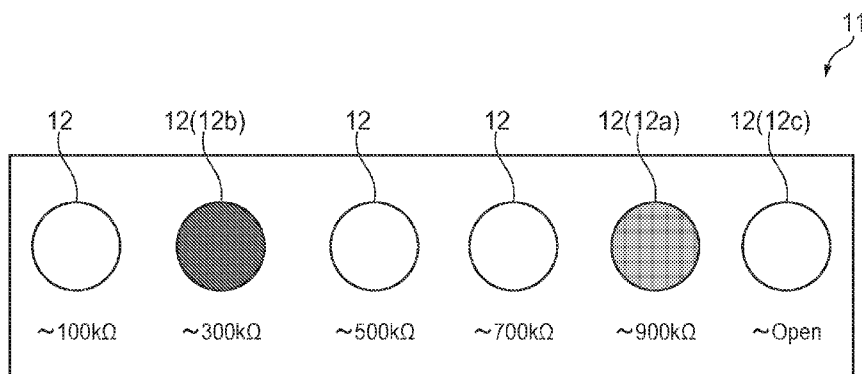


FIG. 3

(57) Abstract: To provide a leak detector that enables users to easily discern the condition of a leak detecting sensor. A degree of deviation between an output value R1 output from a leak detecting sensor 7 and a leak threshold S set by a leak determining unit 6 are displayed on a leak detector 1. In this case, a user can discern a degree of deviation between the leak threshold S and the output value R1 simply by looking at a display of a display unit 11 provided on a main unit 3 of the leak detector 1 even when unable to see an electrode unit 2 of the leak detecting sensor 7 placed under a floor or the like.

## LEAK DETECTOR

BACKGROUND

5 (Technical Field)

[0001]

The present invention relates to a leak detector.

10 (Background)

[0002]

15 It is well known that variations in electric resistance caused by leaks are conventionally used as a method for detecting leaks under the floors of, for example, factories, apartments, restaurants, coffee shops and the like. For example, in Japanese Unexamined Patent Application Publication No. H6-29825 (Patent Document 1), a determination is made as to the presence of a leak based on output data from electric resistance values using a leak detecting sensor (leak detector) that changes due to the presence of liquid that is not isolated.

20 (Documents of the Related Art)

(Patent Documents)

Patent Document 1: Japanese Unexamined Patent Application Publication No. H6-29825

SUMMARY

(Problem to Be Solved by the Invention)

30 [0004]

The output value from electric resistance of a leak detector like that described above may change over time, when used continuously over long periods of time under a floor or the like, due to temporal factors such as, for example, dirt such as dust accumulating around the leak detecting sensor of the leak detector and the dust further becoming moist from condensation, and the like.

35 Furthermore, if a prescribed threshold is reached as a result of the output value changing, the leak detector may falsely detect a leak even when no liquid is actually leaking. Thus, because the leak detecting sensor of the leak detector is placed in a location, such as under a floor or the like, that cannot be easily observed, it is difficult for users to confirm whether the sensor has become dirty due to dust and the like, and thus it is difficult to discern whether or not the sensor is in a state

where false detection is likely to occur due to temporal factors. Therefore, there is a demand for a leak detector that enables users to easily discern the condition of the leak detecting sensor.

(Means for Solving the Problem)

[0005]

5           A leak detector according to an embodiment of the present invention has a leak detecting sensor that outputs an output value based on an amount of a liquid present in a vicinity of the sensor, a leak determining unit that determines whether the liquid is leaking by setting a leak threshold and then comparing the output value output by the leak detecting sensor to the leak threshold, and a display unit that visually displays a degree of deviation between the output value  
10           and the leak threshold.

[0006]

          With this leak detector, the display unit visually displays a degree of deviation between an output value output from the leak detecting sensor and a leak threshold set by the leak determining unit. The degree of deviation is large when the leak detecting sensor is not very dirty due to dust and the like, and the degree of deviation is small when the sensor is very dirty. Accordingly, it is  
15           easy to ascertain the degree of deviation between the leak threshold and the output value simply by looking at the display of the display unit, even when the leak detecting sensor placed under a floor or the like cannot be seen directly. Thus, a user can easily discern the condition of the leak detecting sensor.

20           [0007]

          In a leak detector according to a different embodiment, the display unit displays information corresponding to the output value in a first display position and displays information corresponding to the leak threshold in a second display position, and a gap between the first display position and the second display position may narrow as the degree of deviation becomes  
25           smaller. In this case, the gap between the first display position and the second display position widens when the leak detecting sensor is not very dirty due to dust and the like such that the degree of deviation is large, while the gap narrows as the sensor becomes very dirty such that the degree of deviation becomes small. Therefore, the user can directly discern the condition of the leak detecting sensor simply by looking at the display of the display unit.

30           [0008]

          A leak detector according to a different embodiment also has an abnormality determining unit that determines that an abnormality exists when the output value is outside a range of a predetermined value, and the display unit may display information related to the abnormality based on a determination result of the abnormality determining unit. When there is an abnormality in a

circuit, the degree of deviation between the output value and the leak threshold becomes either extremely large or extremely small. Accordingly, it is easy to discern that the information displayed on the display unit is not based on a normal output value. Thus, the user can easily discern the condition of the leak detecting sensor.

5 (Effect of the Invention)

[0009]

According to the present invention, a user can easily discern the condition of a leak detecting sensor.

10 BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a schematic view illustrating an embodiment of a leak detector according to the present invention.

FIG. 2 illustrates temporal changes in an output value.

15 FIG. 3 is a view illustrating a display unit.

FIG. 4 is a view illustrating an altered example of the display unit.

DETAILED DESCRIPTION

[0011]

20 Preferred embodiments of the leak detector according to the present invention will be described below with reference to the figures.

[0012]

FIG. 1 is a schematic view illustrating an embodiment of a leak detector according to the present invention. A leak detector 1 is placed under the floor and the like of, for example, a building to detect leaks of liquids and to notify a user when a leak has been detected. In the present embodiment in particular, the leak detector 1 detects, for example, leaks of conductive liquids such as tap water, seawater, industrial waste water, solvents, and the like. As illustrated in FIG. 1, the leak detector 1 has an electrode unit 2, a main unit 3, and a power supply unit 4.

[0013]

30 The electrode unit 2 configures an output value calculating unit 5 and a leak detecting sensor 7 incorporated in the main unit 3. The electrode unit 2 has separated electrodes 2a and 2b. More specifically, the electrode unit 2 forms a flat, substantially cylindrical shape wherein long, slender shaped electrodes 2a and 2b are arranged separate from one another, and curve around an outer circumference on the outer circumference side of a bottom surface, for example. The

electrode unit 2 is electrically connected to the output value calculating unit 5 incorporated in the main unit 3 by a cable 10 and gets power from the main unit 3 side through the cable 10. The output value calculating unit 5 calculates electric resistance based on a drop in voltage between the electrodes 2a and 2b of the electrode unit 2, and outputs an output value R1 for the electric resistance to a leak determining unit 6 incorporated in the main unit 3. The output value R1 varies based on the amount of a liquid present in a vicinity of the electrode unit 2, especially between the electrodes 2a and 2b.

[0014]

The main unit 3 provides, for example in an interior of a box shaped case, a microprocessor that performs processing such as, for example, leak determination and sensor voltage control. Furthermore, the main unit 3 has an input unit that sets the leak detector 1, a display unit 11 (described in detail below) that displays, for example, the presence of a leak, and a buzzer that gives notification that there has been a leak. The input unit is configured from a rotary switch, but may be configured from a push button or a volume knob as well.

[0015]

The microprocessor includes the output value calculating unit 5 that calculates electric resistance based on a drop in voltage between the electrodes 2a and 2b of the electrode unit 2, the leak determining unit 6 that determines the presence of a liquid leak based on the output value R1 output from the output value calculating unit 5, a display control unit 13 that controls the display unit 11 based on a leak threshold S set by the leak determining unit 6 and the output value R1, and an abnormality determining unit 14 that determines there is an abnormality in the leak detector 1 when the output value is outside a predetermined range. The leak determining unit 6 can set the leak threshold S, which the unit compares to the output value R1 to determine the presence of a leak. The leak determining unit 6 is able to determine that a leak has occurred based on the fact that the output value R1 has reached the leak threshold S.

[0016]

As illustrated in FIG. 2, the leak threshold S may be set to a predetermined value that does not vary over time. Note that, in FIG. 2, the vertical axis indicates electric resistance and the horizontal axis indicates the passage of time. The leak threshold S is, for example, set to a value that is at least lower than the output value R1 when it is dry between the electrodes 2a and 2b of the electrode unit 2, and may be set to as low a value as possible as long as leaks are still detectable. Note that, for example, the leak threshold S may change based on the output value R1 or may change over time. The leak threshold S may be set to a value that the user cannot adjust or may be a value the user is able to adjust by operating the input unit. Furthermore, the leak

determining unit 6 can set a threshold for restoring the threshold upon determining that the leak is gone after having previously detected that there was a leak.

[0017]

A power supply unit 4 has a plug 8 for making a connection to an external power source, and an AC/DC converter 9 that electrically connects the plug 8 to the cable 10. The AC/DC converter 9 converts AC 100 V externally fed through the plug 8 to DC 12 V. The AC/DC converter is also electrically connected to the main unit 3 by the cable 10 and feeds DC 12 V to the main unit 3.

[0018]

Next, an example of a method for measuring electric resistance using the leak detecting sensor 7 will be described.

[0019]

Square waves that alternate electric potentials of 5 V and 0 V at 1.0 second cycles are applied, respectively, to the electrodes 2a and 2b of the leak detecting sensor 7. Voltage of 5 V is applied to both the electrodes 2a and 2b for 0.5 seconds and then 0 V is applied for 0.5 seconds. Furthermore, the phases of the square waves applied to the electrodes 2a and 2b are shifted by 0.5 seconds and thus when a voltage of 5 V is being applied to the electrode 2a, 0 V is being applied to the electrode 2b, and, conversely, when 0 V is being applied to the electrode 2a, a voltage of 5 V is being applied to the electrode 2b.

[0020]

The leak detecting sensor 7 outputs the electric resistance from when a voltage of 5 V is being applied to the electrode 2a as the output value R1 to the leak determining unit 6. In the same way, the leak detecting sensor 7 outputs the electric resistance from when a voltage of 5 V is being applied to the electrode 2b as a next output value R1 to the leak determining unit 6. In this way, an output value R1 of the electric resistance between the electrodes 2a and 2b is output to the leak determining unit 6 every 1.0 seconds.

[0021]

Next, the display unit 11 will be described in detail.

[0022]

First, a detailed description of the relationship between the output value R1 and the leak threshold S will be given while referring to FIG. 2, and then displaying by means of the display unit 11 will be described. As described above, the leak determining unit 6 is able to determine that a leak of liquid has occurred based on the timing of when an output value R1 from the leak detecting sensor 7 has reached a previously set leak threshold S. There are cases where, when the

leak detector 1 has been used for a long period of time, dirt such as dust will accumulate in the vicinity of the leak detecting sensor 7 and, furthermore, where liquid will adhere to the sensor due to condensation and the like. In such cases, the output value R1 from the leak detecting sensor 7 will, as illustrated in FIG. 2, gradually approach the leak threshold S with the passage of time even though liquid is actually not leaking. For example, as illustrated in FIG. 2, a degree of deviation (for example, a difference between the output value R1 and the leak threshold S can be illustrated by G1) between the output value R1 and the leak threshold S is large at a point in time t1 just after use begins. When the degree of deviation between the output value R1 and the leak threshold S is large in this way, the output value R1 will not reach the leak threshold S even if the value temporarily drops locally due to noise and the like and thus no false detection will be made. Furthermore, when a leak actually occurs, the output value R1, as illustrated by the double dotted line in the figure, suddenly drops dramatically to thus reach the leak threshold S (see P1 in the figure), and thus the leak is detected quickly. On the other hand, the degree of deviation (for example, a difference between the output value R1 and the threshold S can be illustrated by G2) between the output value R1 and the leak threshold S is small at a point in time t2 after a long period of time has passed since use began. When the degree of deviation between the output value R1 and the leak threshold S is small in this way, the output value R1 will reach the leak threshold S even if the value temporarily drops only locally due to noise and the like, and thus a false detection will be made. Or a false detection will be made due to the output value R1 dropping because of temporal factors even when noise is not generated (see P2 in the figure). Accordingly, the user can discern a condition prone to false detection by discerning the degree of deviation between the output value R1 and the leak threshold S.

[0023]

The display unit 11 visibly displays the degree of deviation between the output value R1 and the leak threshold S. The display unit 11 converts the degree of deviation between the output value R1 and the leak threshold S to a predetermined display method (for example, a display method using an LED (Light Emitting Diode), a display method using a liquid crystal, or the like) and displays the degree of deviation. Furthermore, the display unit 11 changes the displayed content based on the degree of deviation between the output value R1 and the leak threshold S. That is, the display unit 11 displays different displayed content when the degree of deviation is large compared to when the degree is small (for example, the unit changes the display position of a lighting position for an LED, changes the display intensity indicated by the color and blinking rate of an LED, or changes a number, a letter, a picture, or the like displayed on a liquid crystal). Note that the control of displayed content such as that described above is executed when the display

control unit 13 performs information processing based on the output value R1 and the leak threshold S and transmits a signal to the display unit 11.

[0024]

FIG. 3 illustrates an example of a display method and display content of the display unit 11 according to the present embodiment. In the present embodiment, the display unit 11 performs display such that the degree of deviation between the output value R1 and the leak threshold S can be confirmed by changing at least the display position of the output value R1 or the display position of the leak threshold S. That is, the display unit 11 displays information corresponding to the output value R1 in first display position 12a, and displays information corresponding to the leak threshold S in second display position 12b. Furthermore, the display unit 11 performs display so that, as the degree of deviation becomes smaller, a gap between the first display position 12a and the second display position 12b becomes narrower. Specifically, as illustrated in FIG. 3, the display unit 11 has a plurality of display positions 12. In the present embodiment, six round display positions 12 are arranged in a single straight line. For example, each display position 12 may be configured of an LED. Of these display positions 12, five of the display positions 12 visually display the value of the output value R1 or the leak threshold S and are arranged from one end, in order, corresponding to electric resistances of 100 k $\Omega$ , 300 k $\Omega$ , 500 k $\Omega$ , 700 k $\Omega$ , and 900 k $\Omega$ . That is, when the output value R1 corresponds to the measured value of the electric resistance of the leak detecting sensor 7, the leak threshold S is also set to the value of a predetermined electric resistance.

[0025]

For example, when the LED of the display position 12 corresponding to the electric resistance of the output value R1 is lighted or blinking, the LED functions as the first display position 12a for displaying the information of the electric resistance of the output value R1. Furthermore, when the LED of the display position 12 corresponding to the electric resistance of the leak threshold S is lighted or blinking, the LED functions as the second display position 12b for displaying the information of the electric resistance of the leak threshold S. In the example illustrated in FIG. 3, by being lighted or caused to blink due to the fact that the output value R1 is greater than 700 k $\Omega$  and is 900 k $\Omega$  or less, the display position 12 fifth from the left in the figure functions as the first display position 12a corresponding to the output value R1. By being lighted or caused to blink due to the fact that the threshold S is greater than 100 k $\Omega$  and is 300 k $\Omega$  or less, the display position 12 second from the left in the figure functions as the second display position 12b corresponding to the threshold S. Furthermore, as the output value R1 gradually decreases as the use period of the leak detector 1 become longer, the first display position 12a draws closer to

the second display position 12b (that is, the first display position 12a moves away from the LED on the right side in the figure toward the LED on the left side). Note that when the electric resistance of the output value R1 and the electric resistance of the leak threshold S are equal, the information of the electric resistance of the output value R1 and of leak threshold S may be displayed by having the one corresponding LED blink rapidly or light up with a different color. In such a case, the one display position 12 functions as both the first display position 12a and as the second display position 12b simultaneously. Accordingly, the gap between the first display position 12a where the LEDs blink and the second display position 12b where the LEDs are lighted visually displays the degree of deviation between the output value R1 and the leak threshold S. Furthermore, the narrower the gap between the first display position 12a and the second display position 12b becomes, the closer the output value R1 draws to the leak threshold S, which indicates that the amount of dust adhering to the leak detecting sensor 7 is increasing, the effects of temporal factors are growing larger, and that the detector is becoming prone to false detections.

[0026]

Note that, as illustrated in FIG. 2, a value R2, obtained by smoothing the output value R1, may be applied as the value for displaying the information of the electric resistance caused by the first display position 12a instead of the output value R1, which is a directly measured value. The value R2 can be, for example, the average movement of the output value R1, in which case, the first display position 12a can be kept from moving frequently due to minute movements of the output value R1 even when the output value R1 is close to a boundary of an electric resistance corresponding to display positions 12 that are adjacent to one another.

[0027]

The abnormality determining unit 14 determines whether or not the output value R1 is outside a predetermined range. For example, the abnormality determining unit 14 may determine that the output value R1 is outside a predetermined range when an output value R1 equal to or greater than a predetermined value is larger than the electric resistance in a case where there is air, which is an insulating body, between the electrodes 2a and 2b. Furthermore, for example, the abnormality determining unit 14 may also determine that the output value R1 is outside a predetermined range when an output value R1 equal to or greater than a predetermined value is smaller than the electric resistance in a case where there is conductive water between the electrodes 2a and 2b. When the abnormality determining unit 14 determines that the output value R1 is outside a predetermined range, the leak detector determines that there is an abnormality, and the display unit 11 displays information related to the abnormality based on a determination result.

For example, one of the display positions 12 (abnormality display position 12c) of the display unit 11 is lighted when the output value R1 is outside a predetermined range. Examples of cases where the output value R1 is outside a predetermined range include cases where there are abnormalities in the circuit due to disconnections, poor connections, shorts, and the like.

[0028]

As described above, in the leak detector 1, the display unit 11 visually displays a degree of deviation between the output value R output from the leak detecting sensor 7 and the leak threshold S set by the leak determining unit 6. For example, because a conventional leak detector does not have a display unit 11 like that of the present embodiment, a buzzer or the like will sound due to a false detection, even though no leak has actually occurred, when the output value R1 reaches the leak threshold S because the leak detecting sensor 7 has become dirty from dust and the like. Furthermore, because the leak detecting sensor 7 is typically placed in a location that is difficult to observe, such as under a floor or the like, it is difficult for a user to confirm the condition of the leak detecting sensor 7. That is, there are cases where the user cannot, even when the use period is long and the condition is prone to a false detection being made, discern this condition beforehand and thus only becomes aware that dust and the like has accumulated when the false detection is actually made. On the other hand, in the leak detector 1 according to the present embodiment, it is easy to ascertain the degree of deviation between the leak threshold S and the output value R1 simply by looking at the display of the display unit 11 of the main unit 3 even when the electrode unit 2 of the leak detecting sensor 7 placed under a floor or the like cannot be seen directly. Thus, a user can easily discern the condition of the leak detecting sensor 7. Because the user can easily discern the condition of the leak detecting sensor 7 in this way, the user can actually check the leak detecting sensor 7 when, for example, the output value R1 draws close to the leak threshold S, remove any dust that has accumulated, and thus prevent a false detection. Alternatively, the user can confirm and discern the display of the display unit 11 during regular inspections to thus be able to discern, based on past trends of the display unit 11, that a buzzer or the like has probably sounded due to accumulated dust when a leak detection buzzer and the like sounds even though no leak has actually occurred.

[0029]

Furthermore, the display unit 11 displays information corresponding to the output value R1 in the first display position 12a and displays information corresponding to the leak threshold S in the second display position 12b, and the gap between the first display position and a second display position narrows as the degree of deviation becomes smaller. In this case, the gap between the first display position 12a and the second display position 12b widens when the leak detecting

sensor 7 is not very dirty due to dust and the like such that the degree of deviation is large, while the gap narrows as the sensor becomes very dirty such that the degree of deviation becomes small. Therefore, the user can directly discern the condition of the leak detecting sensor 7 simply by looking at the display of the display unit 11.

[0030]

Furthermore, the leak detector 1 provides an abnormality determining unit 14 that determines an abnormality exists when the output value R1 is outside a range of a predetermined value, and the display unit 11 displays information related to the abnormality based on the determination results of the abnormality determining unit 14. When there is an abnormality in the circuit, the degree of deviation between the output value R1 and the leak threshold S becomes either extremely large or extremely small. Accordingly, it is easy to discern that the information displayed on the display unit 11 is not based on a normal output value R1. Thus, a user can easily discern the condition of the leak detecting sensor 7.

[0031]

The present invention is not limited to embodiment described above. For example, in the embodiment described above, the display unit 11 arranged six round display positions 12 aligned in a single line, but the present invention is not limited to such a configuration. For example, each display position 12 may be rectangular as illustrated in FIG. 4. The display positions 12 need not be arranged in one row and may thus also be arranged so as to form an arc or may be arranged two dimensionally. Additionally, as illustrated in FIG. 3 and FIG. 4, the degree of deviation may be displayed without separating the display positions 12 by using, for example, a gauge. For example, a long gauge can be displayed when the period of use is short and the degree of deviation between the output value R1 and the leak threshold S is large, and the gauge can be shortened as the degree of deviation gets smaller. In this case, one end of the gauge corresponds to the first display position 12a and the other end corresponds to the second display position 12b.

Furthermore, in the example in FIG. 3, LEDs were provided in each display position 12 and the first and second display positions 12 were changed by varying which LEDs were lighted. Instead of this, an image of display positions 12 like those illustrated in FIG. 3 and FIG. 4 may be displayed on a liquid crystal display, and then an image that causes lights corresponding to the output value R1 and the leak threshold S to light up can be displayed.

[0032]

Furthermore, displays of 100 k $\Omega$ , 300 k $\Omega$ , 500 k $\Omega$ , 700 k $\Omega$ , and 900 k $\Omega$  were attached to the display positions 12 in the embodiment described above, to thus enable the electric resistances of the output value 1 or the leak threshold S to be understood quantitatively. However, as

illustrated in FIG. 4, the display positions 12 need not display values of quantitative electric resistances. That is, the second display position 12b showing the leak threshold S may be fixed in the display position 12 on the far left side, and the first display position 12a showing the output value R1 may be allowed to vary. The degree of deviation can be discerned directly simply by looking at the width of the gap between the first display position 12a and the second display position 12b in this case as well. When the second display position 12b that displays the leak threshold S is fixed, the second display position 12b may be made visually confirmable by a pattern or text shown on a label or the like without being displayed using an electric display method such as LEDs or liquid crystals. Note that when the leak threshold S is also displayed based on the values of quantitative electric resistances, and when the leak threshold is changed in conjunction with the use period, it becomes possible to change the second display position 12b based on the changes in the leak threshold S.

[0033]

Furthermore, in the embodiment described above, while the display of the degree of deviation between the output level R1 and the leak threshold S was based on the distance between the first display position 12a and the second display position 12b, the display content for discerning the degree of deviation is not particularly limited. For example, the degree of deviation may be made discernable by changing the display intensity. Specifically, just one LED for showing the degree of deviation may be provided where a blinking cycle is long when the degree of deviation is large and the cycle becomes shorter as the degree of deviation gets smaller. Or, the color of the display may be changed. For example, blue may be displayed when the degree of deviation is large, and then the color changed to red as the degree of deviation becomes smaller. The display method that changes the display intensity may be coupled with the display method based on changes in distance such as that in FIG. 3 and FIG. 4. For example, the fifth LED from the left in FIG. 3 corresponds to the first display position 12a and, when the LED is lighted, a blinking cycle can be made long when the output value R1 is close to 900 k $\Omega$ , and then the blinking cycle can be made shorter as the value draws close to 700 k $\Omega$ . Furthermore, the display unit 11 may display the degree of deviation using information such as letters, numbers, pictures, or the like. For example, the unit may display text or pictures that provide warnings or reminders when the degree of deviation becomes small and the possibility of a false detection increases, or the unit may convert the degree of deviation to a number (or quantify the warning level as a number) to display the degree.

[0034]

Furthermore, in the embodiment described above, the abnormal display position 12c was provided in order to display that the output value R1 is outside a predetermined range, however, as illustrated in FIG. 4, it is also acceptable not to provide the abnormal display position 12c. In this case, information related to an abnormality can be displayed by, for example, causing all of the display positions 12 to blink simultaneously or the like.

(Reference Numerals)

[0035]

1...leak detector, 6...leak determining unit, 7...leak detecting sensor, 11...display unit,  
12a...first display position, 12b...second display position, 13...display control unit,  
14...abnormality determining unit, R1...output value, S...leak threshold.

What is Claimed is:

1. A leak detector, comprising:
  - 5 a leak detecting sensor that outputs an output value based on an amount of a liquid present in a vicinity of the sensor;  
a leak determining unit that determines whether the liquid is leaking by setting a leak threshold and then comparing an output value output by the leak detecting sensor to the leak threshold; and
  - 10 a display unit that visually displays a degree of deviation between the output value and the leak threshold.
2. The leak detector according to claim 1, wherein the display unit displays information corresponding to the output value in a first display position and displays information  
15 corresponding to the leak threshold in a second display position, and a gap between the first display position and the second display position narrows as the degree of deviation becomes smaller.
3. The leak detector according to claim 1 or claim 2, further comprising an abnormality  
20 determining unit that determines an abnormality exists when the output value is outside a range of a predetermined value,  
wherein the display unit displays information related to the abnormality based on a determination result of the abnormality determining unit.

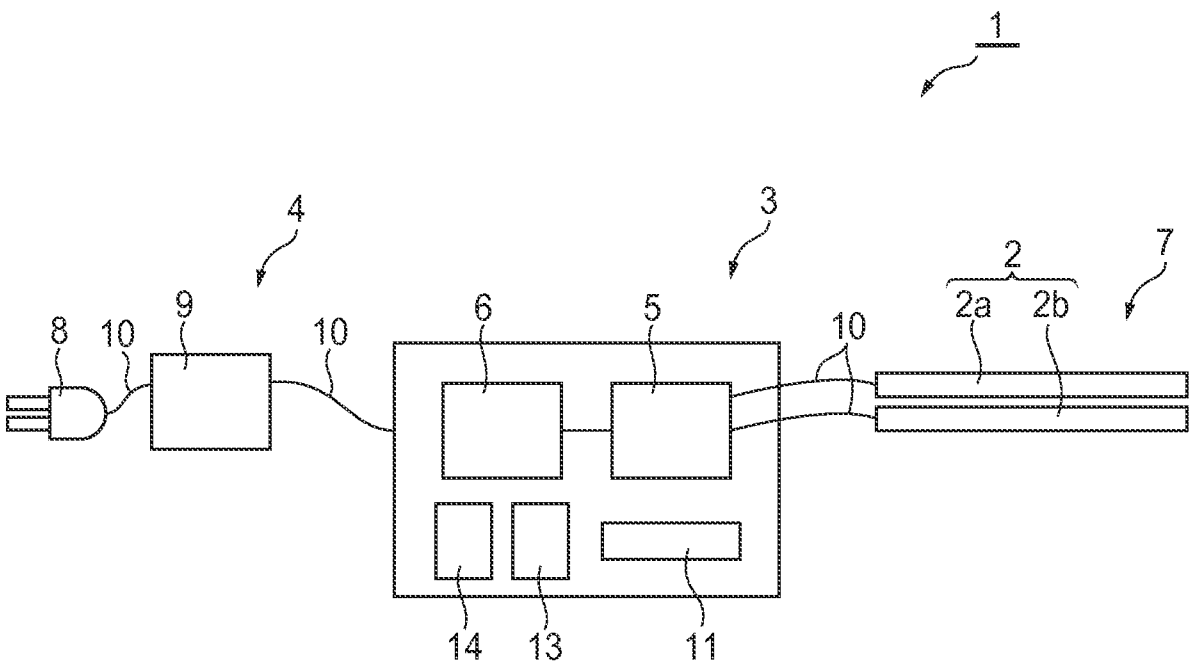


FIG. 1

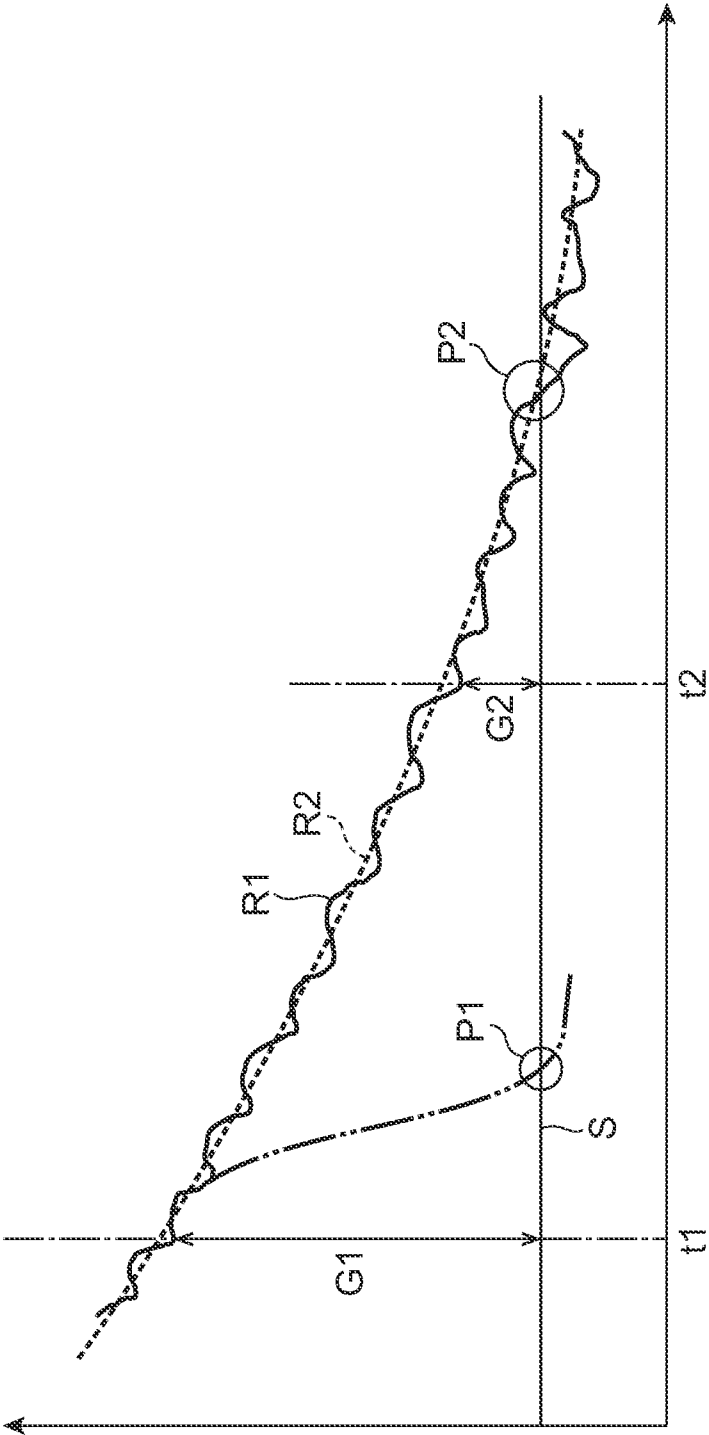
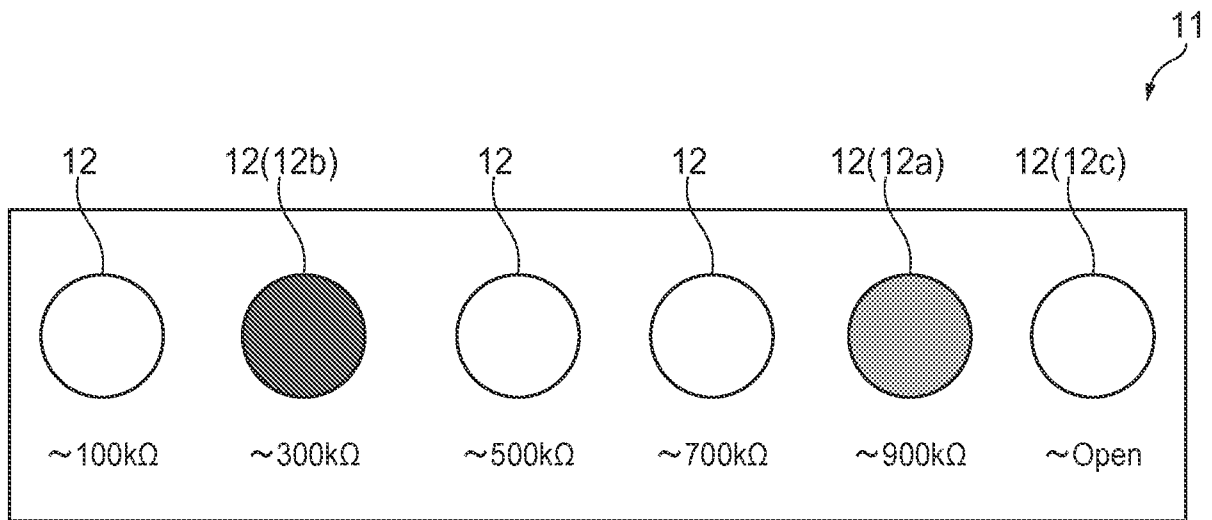
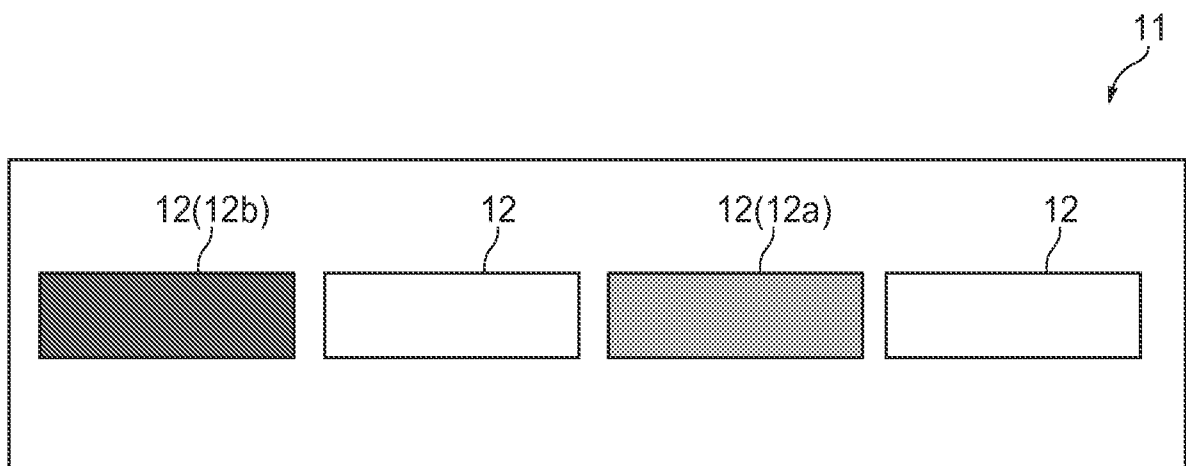


FIG. 2

3/3

*FIG. 3**FIG. 4*

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2015/028726****A. CLASSIFICATION OF SUBJECT MATTER****G01M 3/16(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)

G01M 3/16; H02H 3/00; G01R 31/327; G01R 31/02; G01R 31/14

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) &amp; keywords: leak, light, threshold, display, detector and gap

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                       | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 2012-0146655 A1 (MICHAEL SUCHOFF) 14 June 2012<br>See abstract, paragraphs [0016], [0019]-[0028], claims 1-6 and figures 2, 3.        | 1-3                   |
| A         | US 2006-0146456 A1 (THOMAS S. WILLIAMS) 06 July 2006<br>See abstract, paragraphs [0072]-[0080], claims 1-7 and figures 1-4.              | 1-3                   |
| A         | US 2006-0158798 A1 (JONATHON KEITH JACKSON et al.) 20 July 2006<br>See abstract, paragraphs [0001]-[0006], claims 14-17 and figures 1-4. | 1-3                   |
| A         | US 2002-0180444 A1 (BERNHARD BAUER) 05 December 2002<br>See abstract, paragraphs [0034]-[0039], claims 1-4 and figures 1-5.              | 1-3                   |
| A         | US 6807035 B1 (JOHN RICHARD BALDWIN et al.) 19 October 2004<br>See abstract, column 4, line 17-column 5, line28 and figures 1-4.         | 1-3                   |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

12 August 2015 (12.08.2015)

Date of mailing of the international search report

**12 August 2015 (12.08.2015)**

Name and mailing address of the ISA/KR

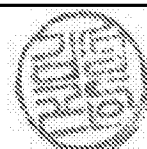
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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2015/028726**

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                                                                                                                                                             | Publication<br>date                                                                                                                                                                                            |
|-------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| US 2012-0146655 A1                        | 14/06/2012          | AU 2013-338224 A1<br>CA 2819134 A1<br>EP 2649462 A2<br>JP 2014-511474 A<br>KR 10-2013-0087557 A<br>US 8907678 B2<br>WO 2012-078958 A2<br>WO 2012-078958 A3                                                                                                             | 04/07/2013<br>14/06/2012<br>16/10/2013<br>15/05/2014<br>06/08/2013<br>09/12/2014<br>14/06/2012<br>13/03/2014                                                                                                   |
| US 2006-0146456 A1                        | 06/07/2006          | CN 101138139 A<br>US 2008-0108252 A1<br>US 7751161 B2<br>WO 2006-074111 A2<br>WO 2006-074111 A3                                                                                                                                                                        | 05/03/2008<br>08/05/2008<br>06/07/2010<br>13/07/2006<br>19/04/2007                                                                                                                                             |
| US 2006-0158798 A1                        | 20/07/2006          | AU 2004-279470 A1<br>AU 279470 B2<br>CN 00477437 C<br>CN 100732605 A<br>CN 101282035 A<br>CN 101282035 B<br>DE 60336163 D1<br>EP 1561267 A1<br>EP 1561267 B1<br>EP 1936772 A2<br>EP 1936772 A3<br>EP 1936772 B1<br>GB 0226111 D0<br>US 7468871 B2<br>WO 2004-042882 A1 | 07/06/2004<br>10/04/2008<br>08/04/2009<br>08/02/2006<br>08/10/2008<br>04/07/2012<br>07/04/2011<br>10/08/2005<br>23/02/2011<br>25/06/2008<br>07/04/2010<br>16/10/2013<br>18/12/2002<br>23/12/2008<br>21/05/2004 |
| US 2002-0180444 A1                        | 05/12/2002          | DE 50101003 D1<br>EP 1150412 A1<br>EP 1277264 A1<br>EP 1277264 B1<br>US 7221548 B2<br>WO 01-82441 A1                                                                                                                                                                   | 24/12/2003<br>31/10/2001<br>22/01/2003<br>19/11/2003<br>22/05/2007<br>01/11/2001                                                                                                                               |
| US 6807035 B1                             | 19/10/2004          | CA 2363743 A1<br>CA 2363743 C<br>MX PA01012157 A                                                                                                                                                                                                                       | 28/05/2002<br>12/11/2013<br>12/08/2004                                                                                                                                                                         |