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(54) Range sensor suitable for a sanitary device

(57) The signal circuit of the range sensor is provided with an operational amplifier 13 for converting the current output I_1 from one of the end terminals of a position sensitive photodetector (PSD) into a voltage, and an operational amplifier 12 for converting the current output I_3 from a common terminal into a voltage. The ratio of the voltages corresponding to the total current values and the current value output from the one end terminal is calculated so as to measure the distance between the object and the range sensor by triangulation. An alternative embodiment (Fig. 4) automatically reduces the intensity of the sensor's light source (2) if the voltage produced by either operational amplifier exceeds a preset value, e.g. if strong disturbing light is entering the photodetector. The sensor may automatically control the flushing operation of a toilet or urinal, the washing operation of a washbasin, the opening of a toilet cover, etc. whenever a user is in a predetermined range.

Fig.1a

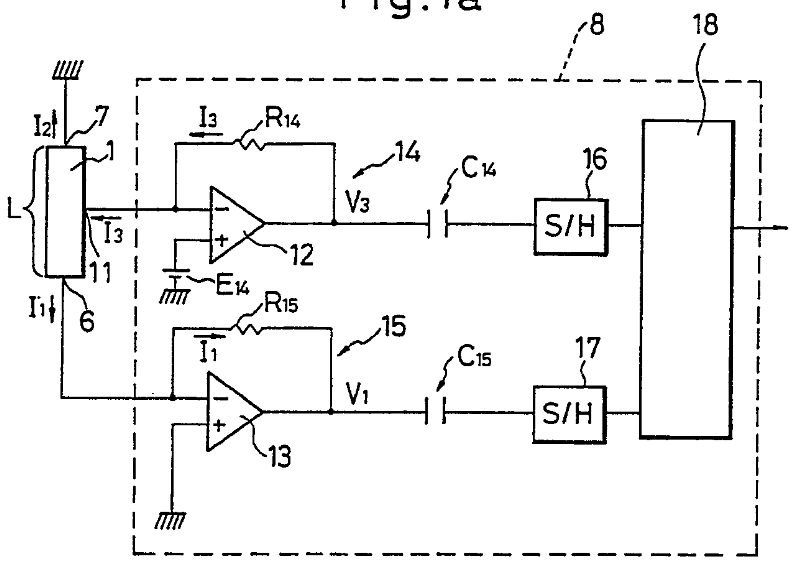

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Fig.1a

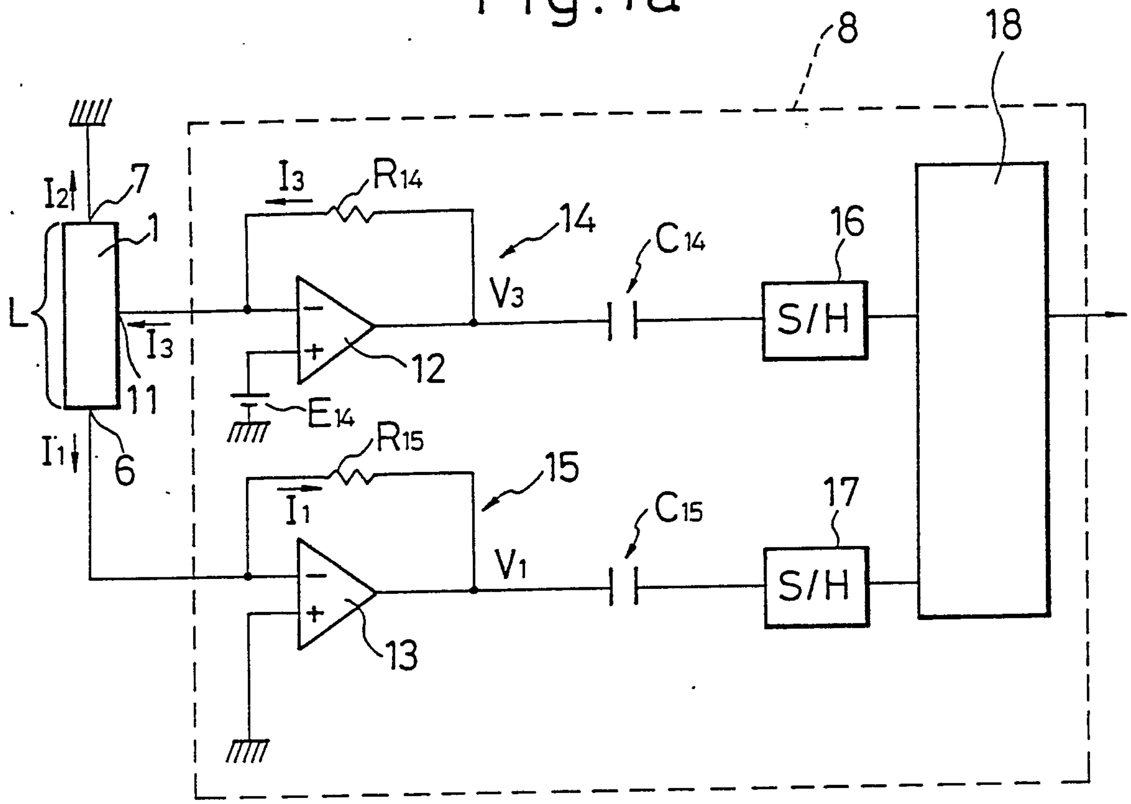

8
18
I2
7
1
I3
R14
14
C14
16
L
V3
S/H
I3
12
11
E14
6
I1
R15
15
I1
C15
17
V1
S/H
13

Fig.1b

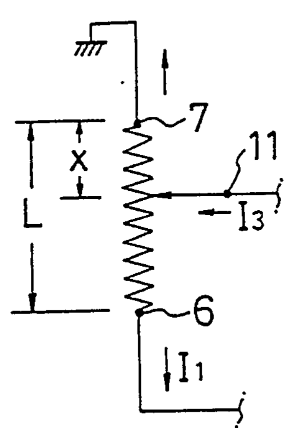

7
X
11
L
I3
6
I1

Fig.1c

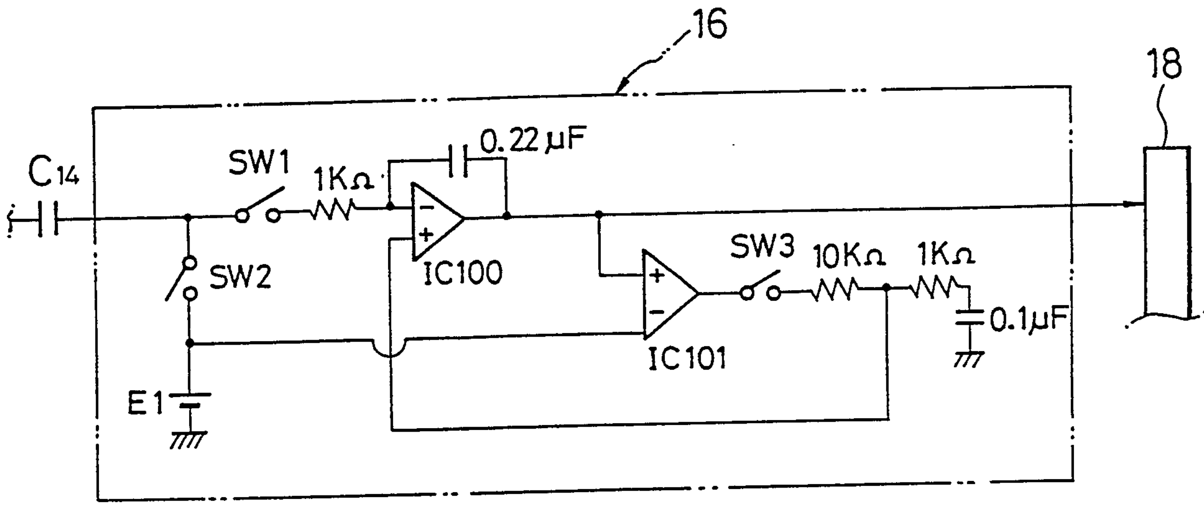

16
18
C14
SW1
1KΩ
0.22μF
SW2
IC100
SW3
10KΩ
1KΩ
0.1μF
IC101
E1

Fig.2

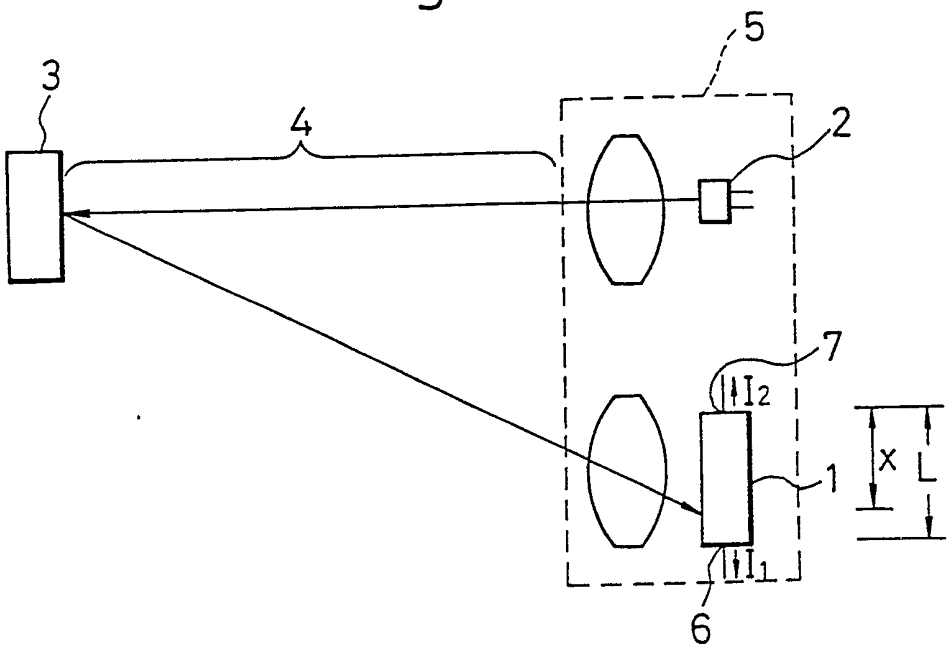

5
3
4
2
7
I_2
X
L
1
I_1
6

Fig. 3

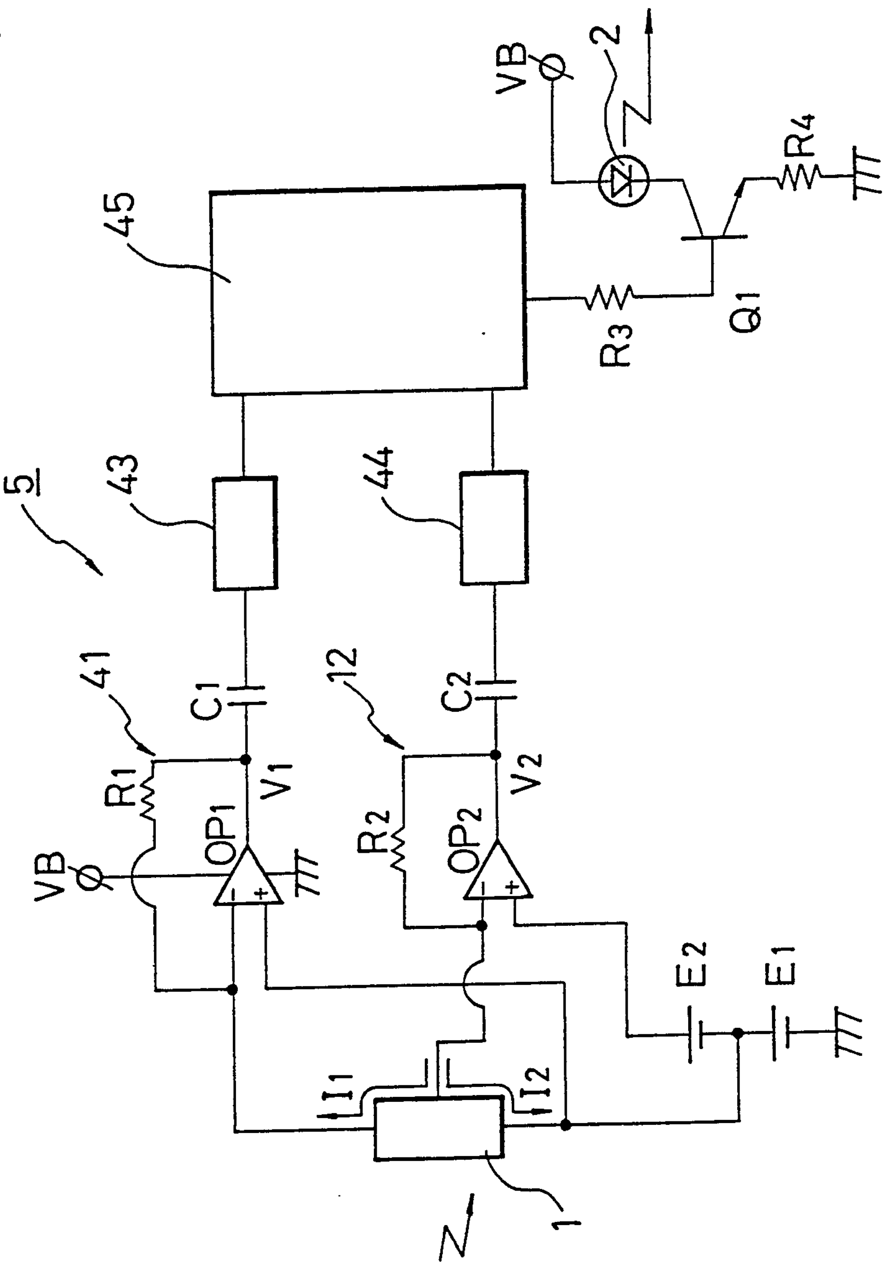
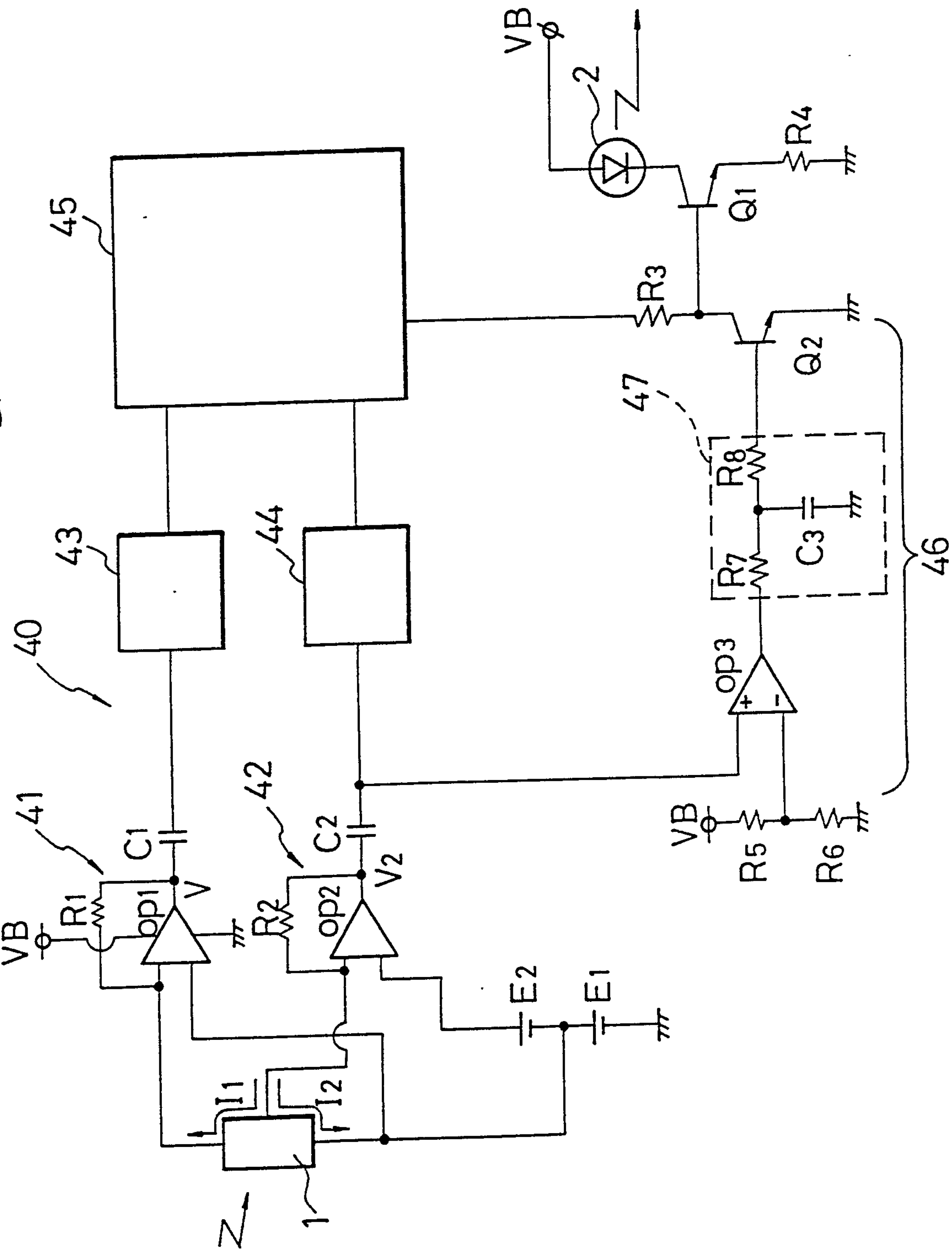


Fig. 4


40
41
42
43
44
45
46
47
VB
R1
R2
R3
R4
R5
R6
R7
R8
C1
C2
C3
op1
op2
op3
V
V2
E1
E2
I1
I2
Q1
Q2
1
2

RANGE SENSOR SUITABLE FOR A SANITARY DEVICE

The present invention relates to a range sensor for measuring the distance between the sensor and an object of measurement by triangulation utilizing a position sensitive photodetector, and to a flushing device for a toilet stool or a washing device for a washstand utilizing the range sensor.

The present invention relates to a sanitary device such as an automatic faucet, toilet stool flushing device, hot-water jetting toilet seat, hand drier and toilet stool equipped with a hot-air fan, and more particularly, to a sanitary device which incorporates a range sensor for measuring the distance between the sensor and an object of measurement by triangulation utilizing a position sensitive photodetector and which uses the data on the distance for a human body detector or the like.

Range sensors such as that shown in Fig. 2 are conventionally utilized in various fields such as an automatic focusing camera and an automation line in a factory. In the range sensor 5 shown in Fig. 2, a position sensitive photodetector (PSD) 1 is utilized as a light receiving element, and the position of the spot on the PSD 1 at which the light projected from a light emitting element 2 and reflected by the object 3 of measurement is detected. The distance 4 between the range sensor 5 and the object 3 of measurement is measured by utilizing the principle of triangulation. The PSD 1 used in this type of conventional range sensor 5 is a light receiving element such as a strip of silicon photodiode. In this range sensor 5, the position of the focus, i.e., the spot on the plane of the PSD 1 at which the light reflected by the object 3 of measurement converges, is calculated from the photoelectric current values obtained from both end terminals 6,7 of the PSD 1. From the position obtained, the distance 4 between the range sensor 5 and the object 3 of measurement is calculated.

To state this concretely, the current values I_1, I_2 obtained from both end terminals 6,7 of the PSD 1 are converted into voltage values V_1, V_2 the difference $(V_1 - V_2)$ between the voltage values and the sum $(V_1 + V_2)$ thereof 2 are obtained, and the distance 4 is calculated from the result of the division of the difference by the sum.

Such a range sensor is utilized, for example, in an automatic flushing device for a toilet stool, as described in Japanese Patent Laid-Open No. 256807/1992.

In the conventional range sensor, however, since operations such as current/voltage conversion, subtraction and addition are executed by analog processing which use the respective operational amplifiers, many amplifiers are required. As a result, the distance obtained contains the errors produced by the operational amplifiers themselves.

Sanitary devices such as an automatic faucet, toilet stool flushing device, hot-water jetting toilet seat, hand drier and toilet stool equipped with a hot-air fan which adopts a range sensor so as to detect a human body or the like and control the driving operation of an electromagnetic valve, a hot-air fan or the like which are known conventionally. In the range sensor 5 shown in Fig. 2, a position sensitive photodetector (PSD) 1 is utilized as a light receiving element, and the position of the spot on the PSD 1 at which the light projected from a light emitting element 2 and reflected by the object 3 of measurement is received is detected.

The distance 4 between the range sensor 5 and the object 3 of measurement is calculated on the basis of the voltage values which are obtained by converting the photoelectric current values output from two terminals of the position sensitive photodetector 1 in accordance with the principle of triangulation.

Fig. 3 is a circuit diagram of the range sensor 5 used for a conventional sanitary device. Current/voltage converters 11, 12 are used so as to convert the photoelectric current values obtained from two terminals of the position sensitive photodetector 1 into voltage values V_1, V_2 as shown in Fig. 3. The current/voltage converter 41 is composed of an operational amplifier OP_1 and a resistor R_1, and the current/voltage converter 42 is composed of an operational amplifier OP_2 and a resistor R_2.

A capacitor C_1 is connected to the output side of the operational amplifier OP_1 and a capacitor C_2 is connected to the output side of the operational amplifier OP_2. An integrator 43 is connected to the capacitor C_1 and an integrator 44 is connected to the capacitor C_2. The integrators 43,44 are provided so as to average the voltage values V_1,V_2 output from the current/voltage converters 41,42. The voltage values V_1,V_2 averaged by the integrators 43,44 are input to a microcomputer 45. The microcomputer 45 calculates the distance 4 between the position sensitive photodetector 1 and the object 3 of measurement on the basis of the averaged voltage values V_1,V_2 in accordance with the principle of triangulation.

The integrators 43,44 are the same as the sampling-holding circuit 16,17. The integrators 43,44 integrate input voltages only during the predetermined sampling time, and hold them during the holding time.

A transistor Q_1 is connected to the microcomputer 45 through a resistor R_3. When a light projection pulse is output from the microcomputer 45, the transistor Q_1 is turned on in synchronism with the light projection pulse. When the transistor Q_1 is turned on, a current is supplied from a supply voltage VB to the light emitting element 2. In other words, light is intermittently projected from the light emitting element 2.

The light intermittently projected from the light emitting element 2 and reflected by the object of measurement is intermittently received by the position sensitive photodetector 1. As a result, the voltage values V_1,V_2 output from the current/voltage converters 41,42 when light is projected differ from the voltage values V_1,V_2 when light is not projected. For this reason, the microcomputer 45 calculates the variations of the voltage values V_1,V_2 at the respective times, and the distance 4 between the position sensitive photodetector 1 and the object 3 of measurement is calculated on the basis of the variations.

In the circuit of the range sensor 5, shown in Fig. 3 the voltage value V_1 output from the current/voltage converter 11 is based on the difference from a reference voltage E_1 ($V_1 = E_1 - I_1.R_1$), and the voltage value V_2 output from the current/voltage converter 12 is based on the difference from a reference voltage $(E_1 + E_2)$ $\{V_2 = (E_1 + E_2) + (I_1 + I_2).R_2\}$. The operational amplifiers OP_1,OP_2 cannot output a lower voltage than a ground voltage. In addition, the operational amplifiers OP_1,OP_2 cannot output a higher voltage than the supply voltage VB. Therefore, if the light from the light emitting element 2 enters the position sensitive photodetector 1 while comparatively strong disturbing light enters the position sensitive photodetector 1, and if the photoelectric current value output from a terminal of the position sensitive photodetector 1 is too large, the voltage $(E_1 + E_2) + (I_1 + I_2).R$, which corresponds to the photoelectric current value exceeds the supply voltage VB, so that the voltage V_2 output from the current/voltage converter 42 when light is projected does not vary in proportion to the light which is projected from the light emitting element 2, reflected by the object and received by the position sensitive photodetector 1. As a result, it is impossible to accurately calculate the distance between the position sensitive photodetector 1 and the object of measurement.

Namely, a maximum output voltage $V_{out.max}$ of an operational amplifier is generally approximately 70% of a supply voltage supplied thereto. When an input voltage V_{in} is lower than a voltage $V_{in.max}$ (which yields the maximum output voltage $V_{out.max}$ is an output voltage V_{out} varies in proportion to the input voltage V_{in}.

When the input voltage V_{in} is higher than the voltage $V_{in.max}$, the output voltage V_{out} does not vary in proportion to the input voltage V_{in}.

As a result, the output voltage V_{out} does not vary in proportion to the distance between the photodetector 1 and the object.

It is an aim of the present invention to eliminate the above-described problem in the related art and to provide a range sensor which has the measuring accuracy required of a range sensor, particularly for detecting a human body at toilet stand or a washstand, and which can reduce the errors produced by the operational amplifiers themselves by reducing the number of the amplifiers necessary in the circuit structure.

It is another aim of the present invention to provide a device utilizing this range sensor.

It is still another aim of the present invention to eliminate the above-described problem in the related art and to provide a sanitary device which can detect a human body or the like and accurately control the electromagnetic valve or the like by lowering the light projection level of the light emitting element 2 when the voltage value V_2 output from the current/voltage converter 42 exceeds a predetermined value due to the disturbing light which enters the position sensitive photodetector 1 so as to vary the voltage value V_2 in proportion to the received reflected light without exceeding the ground voltage VB.

Accordingly, in a first aspect of the present invention, there is provided a range sensor comprising: a light emitting element for projecting light to an object of measurement; a light receiving element constituted by a position sensitive photodetector for proportionally outputting the photoelectric currents obtained from both end terminals thereof in correspondence with the position at which light enters the position sensitive photodetector; and a signal processing circuit for processing the signals for photoelectric currents which flow through a common terminal and one of both end terminals of the position sensitive photodetector; the signal processing circuit including current/voltage converters for converting the photoelectric currents which flow through the common terminal and the one end terminal into voltages, and a divider for calculating the ratio of the photoelectric currents which flow through the common terminal and the one end terminal by calculating the ratio of the respective voltages obtained by the current/voltage converters, thereby detecting the position at which the light projected from the light emitting element and reflected by the object of measurement enters the position sensitive photodetector so as to measure the distance between the range sensor and the object of measurement on the basis of the position.

In a second aspect of the present invention, there is provided an automatic urinal flushing device incorporating the above-described range sensor which detects the distance between a user and the range sensor and which automatically flushes a urinal when the user enters a predetermined range.

In a third aspect of the present invention, there is provided an automatic toilet stool flushing device incorporating the above-described range sensor which detects the distance between a user and the range sensor and which automatically flushes a toilet stool when the user enters a predetermined range.

In a fourth aspect of the present invention, there is provided an automatic toilet stool flushing device incorporating the above-described range sensor which detects the distance between a user and the range sensor and which automatically flushes a toilet stool when the user leaves a predetermined range.

In a fifth aspect of the present invention, there is provided an automatic washing device for a washstand incorporating the above-described range sensor which detects the distance between a user and the range sensor which automatically turns on the water when the user enters a predetermined range.

In a sixth aspect of the present invention, there is provided an automatic washing device for a washstand incorporating the above-described range sensor which detects the distance between a user and the range sensor which automatically blows out hot air when the user enters a predetermined range.

In a seventh aspect of the present invention, there is provided an automatic washing device for a washstand incorporating the above-described range sensor and which detects the distance between a user and the range sensor which automatically drops liquid soap when the user enters a predetermined range.

In an eighth aspect of the present invention, there is provided a hot-water jetting toilet stool having a cover opening mechanism and incorporating the above-described range sensor and which detects the distance between a user and the range sensor which automomatically opens or closes the cover when the user enters a predetermined range.

In a ninth aspect of the present invention, there is provided a toilet stool seat opening device incorporating the above-described range sensor which detects the distance between a user and the range sensor and which automatically opens or closes the seat when the user enters a predetermined range.

A range sensor according to the present invention adopts a signal processing circuit for processing the signals for the photoelectric currents which flow through the common terminal and one end terminal of the position sensitive photodetector. The signal processing circuit is constituted only by current/voltage converters for converting the photoelectric currents which flow through the common terminal and the one end terminal into voltages and is dispensed with an adder or a subtractor which is necessary in the conventional range sensor. It is therefore possible to reduce the number of operational amplifiers in the range sensor, thereby reducing the influence of the errors of the operational amplifiers themselves and enhancing the measuring accuracy.

The range sensor is utilized in a device for starting or stopping various operations of a toilet stool, a urinal or a washstand.

The present invention also provides a sanitary device such as an automatic faucet and a toilet stool flushing device provided with a range sensor, the range sensor comprising: a light emitting element for intermittently projecting light to an object of measurement; a position sensitive photodetector as a light receiving element to which a photoelectric current is applied in proportion to the position at which light enters;

current/voltage converters for converting the photoelectric currents output from the position sensitive photodetector into voltages; integrators for averaging the respective voltages output from the current/voltage converters; a distance computer for calculating the distance between the object of measurement and the position sensitive photodetector on the basis of the averaged voltages in accordance with the principle of triangulation; and a light projection level lowering circuit for lowering the light projection level of the light emitting element when the voltage output from one of the current/voltage converters exceeds a preset value.

According to the range sensor having the above-described structure, since the light projection level lowering circuit lowers the light projection level to an appropriate level in accordance with the output voltage of a current/voltage converter when the output voltage exceeds a preset value due to the disturbing light which enters the position sensitive photodetector, the voltage takes a value which is proportional to the received reflected light, so that the distance computer can accurately calculate the distance between the position sensitive photodetector and the object of measurement.

An embodiment of a range sensor according to the present invention will be explained hereinbelow with reference to the accompanying drawings, in which;

Fig. 1a is a circuit diagram of a signal processing circuit of an embodiment of a range sensor in accordance with the present invention;

Fig. 1b is a circuit diagram of a PSD;

Fig. 1c is a circuit diagram of a sampling-holding circuit;

Fig. 2 is a schematic view of the basic structure of a range sensor;

Fig. 3 is a circuit block diagram of a conventional range sensor; and

Fig. 4 is a circuit block diagram of a range sensor of an embodiment of a sanitary device in accordance with the present invention.

The basic structure of a range sensor is the same as that shown in Fig. 2. The characteristic of the range sensor of the present invention lies in a signal processing circuit 8 for processing the signals output from the PSD 1.

As shown in Fig. 2, the light projected from the light emitting element 2 to the object 3 of measurement is reflected by the surface of the object 3 toward the range sensor 5. The reflected light forms a spot on a specific position of the PSD 1.

The PSD 1 produces charges which are proportional to the light energy of the spot. The charges are output from both end terminals 6,7 of the PSD 1 as photoelectric currents.

As shown in Figs. 1a and 1b, one 7 of both end terminals 6,7 is grounded (the value of the current flowing from the terminal 7 is assumed to be I_2), and the value I_1 of the current which flows through the other terminal 6 and the value I_3 of the current which flows through a common terminal 11 are processed.

In accordance with the characteristics of the PSD 1, the photoelectric currents I_1, I_2 which are distributed in reverse proportion to the distances between the spot and the respective terminals 6,7 are taken out of both end terminals 6,7.

When a spot of light is closest to the end terminal 7, the value of the photoelectric current I_2 taken out of the end terminal 6 or 7 equal to the current I_3, and the value of the photoelectric current I_1 taken out of the end terminal 6 is 0.

When the spot is formed at a point distant from the terminal 6 by a distance "X_2", the current values I_1 and I_3 are represented by the following equation:

$$I_1 = I_3\, X/L \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Wherein "L" is an interval between the terminal 6 and 7 (which corresponds to the length of the PSD 1). The value I_3 of the current which flows into the common terminal 11 is represented by the following equation:

$$I_3 = I_1 + I_2$$

The photoelectric current values I_1, I_3, respectively, are first converted into voltage values V_1, V_3 by current/voltage converters 14,15 constituted by operational amplifiers 12,13 and resistances R_{14}, R_{15}.

The operational amplifier 12 has a non-inversion input terminal which is connected to the common terminal 11 and an inversion terminal which is connected to a battery E_{14} having voltage of approximately 2.5 volts. The operational amplifier 12 has a non-inversion input terminal which is connected to the terminal 6 and an inversion terminal which is grounded.

The output terminal of the operational amplifier 12 is connected to the microcomputer 18 via a capacitor C_{14} and a sampling-holding circuit 16. The output terminal of the operational ampifier 13 is connected to the microcomputer 18 via a capacitor C_{14} and a sampling-holding circuit 17. Each one of the non-inversion input and output terminals of the operational amplifiers 12,13 is connected to each other via the resistances R_{14},R_{15}.

The capacitors C_{14},C_{15} are rechargeable by the battery E_1 of sampling-holding circuit 16,17 as described later.

In this embodiment, the light emitting element of the range sensor is lighted in a pulse pattern. During the period while the light-receiving element is receiving light, the currents I_3, I_1 do not flow, and the voltage charged in the capacitors C_{14},C_{15} becomes equal to the voltage of the battery E_1.

Each of the operational amplifiers 12,13 is a model #S 3272 of Hamamatsu Photonics Corporation in Japan. The resistors 14, 15 have a resistance of 4.3 MΩ. The capacitors C_{14},C_{15} have a capacitance of 0.047μF.

Since the voltage of the inversion input terminal and the voltage of the non-inversion input terminal of the operational amplifiers are the same because of an imaginary short-circuit, the voltage of the inversion input terminal of the operational amplifier 12 is E and the voltage of the inversion input terminal of the operational amplifier 13 is 0. (The value E is the voltage of the battery E_{14}.) The currents I_3, I_1 flow in the resistors R_{14}, R_{15} in the direction of arrows shown in Fig. 1a. Accordingly, the output terminal voltages V_3, V_1 of the operational amplifiers 12,13 are described in the following equations.

$$V_3 = E + R_{14} \cdot I_3$$

$$V_1 = R_{15} \cdot I_1$$

From the above equations, the currents I_3, I_1 are calculated by the following equations.

$$I_3 = \frac{V_3 - E}{R_{14}} \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$I_1 = \frac{V_1}{R_{15}} \quad \ldots\ldots\ldots\ldots \quad (3)$$

As described above, the voltage value V_3 is the value KI_0, which is determined only by the diameter of the light spot and the intensity of the light irrespective of the position of the spot. Since the intensity of the received light is judged from the result of the addition, it is possible to automatically adjust the light emission. For example, when the value is small, the intensity of light is increased.

The signals indicating the voltage values V_3, V_1 are input to a divider 18 of a microcomputer after the output timings thereof are adjusted by sample-hold (S.H) circuits 16,17. A divided value X/L is calculated as follows.

$$\frac{X}{L} = \frac{I_1}{I_3} \quad \cdots \cdots \cdots \cdots \cdots \cdots \quad (1)$$

$$= \frac{\frac{V_1}{R_{15}}}{\frac{V_3 - E}{R_{14}}}$$

$$= \frac{V_1}{V_3 - E}$$

$$(\because R_{14} = R_{15} = 4.3\ M\Omega)$$

In order to obtain the distance X of the spot from the end terminal, the result of the value [X/L] is multiplied by L. After the distance X of the spot is calculated, it is possible to calculate the distance 4 between the range sensor 5 and the object 3 by triangulation.

The construction of sampling-holding circuit 16 is explained now with reference of Fig. 1c. The sampling-holding circuit 17 has the same construction as of the circuit 16.

The battery E_1 is connected to one of the terminals of the capacitor C_{14} via a switch SW_2, and also the inversion input terminal of an operational amplifier Ic 100 is connected to the terminal of the capacitor C_{14} via a switch SW_1 and a resistor of 1 KΩ.

The output terminal of the operational amplifier Ic 100 is connected to a non-inversion input terminal of the operational amplifier Ic 100 via a capacitor having a capacitance of 0.22μF. The output terminal of operational amplifier Ic 100 is also connected to the microcomputer 18 and the non-inversion input terminal of the operational amplifier Ic 101. The non-inversion input terminal of the operational amplifier Ic 101 is connected to the battery E_1. The output terminal of the operational amplifier Ic 101 is grounded via a switch SW_3, a resistor of 10 KΩ, a resistor having value of 1 KΩ and a capacitor having capacitance of 0.1μF.

The portion where the resistor of 10 KΩ and the resisitor of 1 KΩ is connected is communicated to the non-inversion input terminal of the amplifier Ic 100.

The amplifier Ic 100 is a model #TL082 of Texas Instruments and the amplifier Ic 101 is a model #μ PC4570 of NEC. The switches SW_1, SW_2 and SW_3 are controlled to be turned on and off by signals from the microcomputer 18.

The sampling-holding circuit acts as follows:

(1) When all switches SW_1, SW_2 and SW_3 are turned on, an analog level of the circuit is initialized and an output thereof becomes E_1 (the voltage of the battery E_1).

(2) When only the switch SW_1 is turned on and the switches SW_2 and SW_3 are turned off, the voltage V_3 is sampled.

(3) When the switches SW_1 and SW_3 are turned off and only the switch SW_2 is turned on, the sampling voltage is held. In this case, the capacitor C_{14}, is charged by the battery E_1.

In the above-described division, V_1 is used as the dividend. Alternatively, it is possible to ground the terminal 6 and use the value V_2 obtained by converting the current value I_2 output from the terminal 7 into a voltage value.

This embodiment is applicable to, for example, an automatic urinal flushing device which automatically flushes a urinal when a user stands in a predetermined range. In this case, since the distance between the range sensor and the urinal is measured, it is possible to accurately automatically flush the urinal irrespective of the color of the clothes, or the like of the user.

This embodiment may also be applied to an automatic toilet stool flushing device which automatically flushes a toilet stool when a user enters or leaves a predetermined range by detecting the distance between the user and the range sensor. According to such a device, since the toilet stool is automatically flushed, there is no fear of the toilet stool making the user sick because of the preceding user who forgets to flush the toilet.

When this embodiment is applied to an automatic washing device for a washstand, it is possible to detect the distance between a user and the range sensor, and when the user enters a predetermined range, it automatically turns on the water, blows out hot air, drops liquid soap, or successively executes these operations, as occasion demands.

If a toilet stool is provided with a cover opening mechanism or a seat opening mechanism, it is possible to detect the distance between a user and the range sensor, and when the user enters a predetermined range, it automatically opens or closes the cover or the seat.

As described above, according to the present invention, it is not necessary to provide an operational amplifier exclusively for addition of the outputs of both end terminals of the PSD or an operational amplifier for subtraction of the outputs. It is therefore possible to reduce the errors produced by the operational amplifiers themselves.

An embodiment of a sanitary device according to the present invention will be explained with reference to Fig. 4. As shown in Fig. 4, a range sensor 40 incorporated into a sanitary device such as automatic faucet, toilet stool flushing device, hot-water jetting toilet seat, hand drier and toilet stool equipped with a hot-air fan is different from the range sensor 5 shown in Fig. 3 in that it includes a light projection level lowering circuit 46. The light projection level lowering circuit 46 lowers the light projection level of the light which is emitted from the light emitting element 2 when the voltage value V_2 output from the current/voltage converter 42 exceeds a predetermined value due to the comparatively strong disturbing light which enters the position sensitive photodetector 1, in order to vary the voltage value V_2 in proportion to the received reflected light, thereby enabling the accurate calculation of the distance between the position sensitive photodetector 1 and the object 3 (human body or the like) of measurement.

The range sensor 40 will be explained hereinunder. The same reference numerals are provided for the elements which are the same as those in the range sensor 5 shown in Fig. 3 and explanation thereof will be omitted.

In Fig. 4, the output voltage V_2 of the current/voltage converter 42 is input to the non-inversion terminal (+) of an operational amplifier OP_3 through the capacitor C_2. A reference voltage which is obtained by dividing the supply voltage VB by resistances R_5 and R_6 is applied to the inversion terminal (-) of the operational amplifier OP_3. An integrator 47 composed of a resistor R_7, a capacitor C_3 and a resistor R_8 is connected to the output terminal of the operational amplifier OP_3.

An output terminal of a NPN transistor Q_2 is connected to the output side of the integrator 17. As the output voltage of the integrator 17 increases the base voltage of the transistor Q_2 increases so that the internal resistance (the resistance between the collector and the emitter) of the transistor Q_2 increases.

A collector of the transistor Q_2 is connected to the microcomputer 45. The collector is also connected to a base of the transistor Q_1 through the resistor R_3. The transistor Q_1 is turned on and off in accordance with the light projection pulse output from the microcomputer 45.

A current is applied from the supply voltage VB to the light emitting element 2 when the transistor Q_1 is turned on, as explained in relation to the conventional range sensor 5.

In the conventional range sensor 5 shown in Fig. 3, since the current applied to the light emitting element 2 is constant, it is impossible to adjust the quantity of light emitted. In contrast, in the present invention, the light projection level lowering circuit 46 can automatically reduce the quantity of light emitted when disturbing light which enters the position sensitive photodetector 1 is stronger than a predetermined level.

In the circuit shown in Fig. 4, the element 1 is the same as the element shown in Fig. 1a. The resistance value of each resistor, the capacitance of each capacitor and the supply voltage VB are as follows.

R_1, R_2	:	4.3 MΩ
R_3	:	2.7 KΩ
R_4	:	1.3 Ω
R_5	:	1.5 KΩ
R_6	:	6.8 KΩ
R_7	:	4.7 KΩ
R_8	:	10 KΩ
C_1, C_2	:	0.047μF
C_3	:	0.1μF
VB	:	12 V

The operation of the light projection level lowering circuit 46 will now be explained.

When the output voltage V_2 of the current/voltage converter 42 is input to the non-inversion terminal (+) of the operational amplifier OP_3, the operational amplifier OP_3 compares the voltage

V_2 with the voltage applied to the inversion terminal (-). If the voltage V_2 exceeds the voltage applied to the inversion terminal (-) due to the strong disturbing light which enters the position sensitive photodetector 1, the operational amplifier OP_3 outputs a positive voltage which corresponds to the difference between both voltages. The output voltage of the operational amplifier OP_3 is output to the base of the transistor Q_2 with delay laid down by a time constant of the circuit constituted by the resistors R_7,R_8 and the capacitor C_3.

When the output voltage of the operational amplifier OP_3 is applied to the base of the transistor Q_2, the internal resistance (the resistance between the collector and the emitter) of the transistor Q_2 is lowered, so that the base voltage of the transistor Q_1 increases. As a result, the internal resistance (the resistance between the collector and the emitter) of the transistor Q_1 increases, which automatically lowers the light projection level of the light emitting element 2. The voltage V_2 therefore varies in proportion to the level of the received light, thereby enabling the microcomputer 45 to calculate accurately the distance 4 between the photodetector 1 and the object.

When the intensity of disturbing light becomes low and the voltage V_2 is lower than the voltage of the inverse terminal of the operational amplifier OP_3, the base voltage of the transistor Q_2 becomes low with delay laid down by the time constant of the integrator 47. As a result, the base voltage of the transistor Q_1 increases, so that more current flows into the light emitting element 2 and the light projection level therefrom increases.

The range sensor 10 in accordance with the present invention can be utilized to detect the user of a urinal, a toilet stool or the like, the user of a washing device for a washstand, the user of a hand drier, etc.

As described above, according to the present invention, a sanitary device such as an automatic faucet and a toilet stool flushing device is provided with a range sensor, and the range sensor comprises: a light emitting element for intermittently projecting light to an object of measurement; a position sensitive photodetector as a light receiving element to which a photoelectric current is applied in proportion to the position at which light enters; current/voltage converters for converting the photoelectric currents output from the position sensitive photodetector into voltages; integrators for averaging the respective voltages output from the current/voltage converters; a distance computer for calculating the distance between the object of measurement and the position sensitive photodetector on the basis of the averaged voltages in accordance with the principle of triangulation; and a light projection level lowering circuit for lowering the light projection level of the light emitting element when the voltage output from one of the current/voltage converters exceeds a preset value. It is therefore possible to lower the light projection level of the light emitting element when the voltage output from one of the current/voltage converters exceeds a predetermined value due to the comparatively strong disturbing light which enters the position sensitive photodetector. The voltage therefore varies in proportion to the received reflected light, thereby enabling the accurate measurement of the distance between the position sensitive photodetector and the object of measurement. Thus, it is possible to accurately control an electromagnetic valve of an automatic faucet, a toilet stool flushing apparatus or the like.

While there has been described what is at present considered to be a preferred embodiment of the invention, it will be understood that various modifications may be made thereto, and it is intended that the appended claims cover all such modifications as fall within the scope of the invention.

CLAIMS:

1. A range sensor comprising:

a light emitting element for projecting light to an object of measurement;

a light receiving element constituted by a position sensitive photodetector for proportionally outputting photoelectric currents obtained from both end terminals thereof in correspondence with the position at which light enters said position sensitive photodetector; and

a signal processing circuit for processing the signals of photoelectric currents which flow through a common terminal and one of said both end terminals of said position sensitive photodetector;

said signal processing circuit including current/voltage converters for converting said photoelectric currents which flow through said common terminal and said one end terminal into voltages, and a divider for calculating the ratio of said photoelectric currents which flow through said common terminal and said one end terminal by calculating the ratio of the respective voltages obtained by said current/voltage converters, thereby detecting the position at which the light projected from said light emitting element and reflected by said object of measurement enters said position sensitive photodetector so as to measure the distance between said range sensor and said object of measurement on the basis of said position.

2. An automatic urinal flushing device incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and a urinal is automatically flushed when the user enters a predetermined range.

3. An automatic toilet stool flushing device incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and a toilet stool is automatically flushed when the user enters a predetermined range.

4. An automatic toilet stool flushing device incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and a toilet is automatically flushed when the user leaves a predetermined range.

5. An automatic washing device for a washstand incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and the water is turned on when the user enters a predetermined range.

6. An automatic washing device for a washstand incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and hot air is is automatically blown out when the user enters a predetermined range.

7. An automatic washing device for a washstand incorporating a

range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and liquid soap is automatically dispensed when the user enters a predetermined range.

8. A hot-water jetting toilet stool provided with a cover opening mechanism incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and the cover is automatically opened or closed when the user enters a predetermined range.

9. A toilet stool seat opening device incorporating a range sensor according to claim 1, wherein the distance between a user and said range sensor is detected by said range sensor and the seat is automatically opened or closed when the user enters a predetermined range.

10. A range sensor as defined in claim 1, wherein each of said current/voltage converters is equipped with an operational amplifier whose inversion terminal is connected to the light receiving element and whose non-inversion terminal is grounded via a battery or directly, and a resistor which connects the inversion terminal and the output terminal of said operational amplifier.

11. A range sensor as defined in claim 10, wherein said output terminal of said operational amplifier of each converter is connected to a sampling-holding circuit via a capacitor.

12. A range sensor as defined in claim 11, wherein said output of said sampling-holding circuit is input to a microcomputer.

13. A sanitary device such as an automatic faucet and a toilet stool flushing device incorporating a range sensor, said range sensor comprising:

a light emitting element for intemittently projecting light to an object of measurement;

a position sensitive photodetector as a light receiving element to which a photoelectric current is applied in proportion to the position at which light enters;

current/voltage converters for converting the photoelectric currents output from said position sensitive photodetector into voltages;

integrators for averaging the respective voltages output from said current/voltage converters;

a distance computer for calculating the distance between said object of measurement and said position sensitive photodetector on the basis of the averaged voltages in accordance with the principle of triangulation; and a light projection level lowering circuit for lowering the light projection level of said light emitting element when the voltage output from one of said current/voltage converters exceeds a preset value.

14. A sanitary device as defined in claim 13, wherein each of said current/voltage converters are equipped with an operational amplifier whose inversion terminal is connected to the light receiving element and whose non-inversion terminal is grounded via a battery and a resistor which connects the inversion terminal and the output terminal of said operational amplifier.

15. A sanitary device as defined in claim 14, wherein an output terminal of said operational amplifiers is connected to said integrator via a capacitor.

16. A sanitary device as defined in claim 15, wherein said output of said integrator is input to a microcomputer.

17. A sanitary device as defined in claim 13, wherein said light projection level lowering circuit has a current controlling means which lowers a current flowing to said light emitting element when a current flowing into said light receiving element becomes more than a predetermined level.

18. A range sensor substantially as hereinbefore described with reference to Figures 1a, 1b, 1c and 2.

19. A sanitary device such as an automatic faucet, toilet stool flushing device, hot-water jetting toilet seat, hand drier and toilet stool equipped with a hot-air fan substantially as hereinbefore described with reference to Figure 4.

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Examiner's report to the Comptroller under Section 17
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(ii) Int Cl (Ed.5) G01B; G01C; G01S 17/46

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE:WPI

Documents considered relevant following a search in respect of Claims :-
1 to 12

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	EP 0188827 A1	(OPTISCHE INDUSTRIE) page 5 line 23 to page 7 line 27	1
X	US 4849781	(OLYMPUS) whole document; column 4 line 9; column 5 line 45	1,10

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