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C E R T I F I C A T E

I, Hiroh Suzuki, a patent attorney, of Mita No. 1 Nagaoka Bldg., 4-3, Mita 3-chome, Minato-ku, Tokyo, Japan, hereby certify that I translated the International Patent Application No. PCT/JP97/03977 filed on October 31, 1997 (31.10.97) and certify that the following is a true and correct translation to the best of my knowledge and belief.

Hiroh Suzuki

Dated this 7th day of July, 1998

SPECIFICATION

A radiation clinical thermometer

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a radiation clinical thermometer which detects thermal radiation energy to measure temperature without contact.

RELATED ARTS

To measure body temperature in a short period of time, a radiation clinical thermometer which allows the one to choose the eardrum for measuring the temperature thereof without contacting the same has been suggested.

For example, the present applicant proposed the radiation clinical thermometer shown in Figs. 10 and 11 in Japanese Patent Application No. Hei-7-294117. Fig.10 is a front elevation view showing the radiation clinical thermometer proposed in Japanese Patent Application No. Hei-7-294117.

The radiation clinical thermometer 1 is a clinical thermometer designed to measure the temperature of the eardrum comprising a main body 4 and a probe 2. The main body 4 is provided with a liquid crystal display element 6 for displaying the body temperature and a measurement switch 5 of a push button structure.

The radiation clinical thermometer 1 operates as follows. First, the measurement switch 5 is pressed to turn on the power for starting temperature measurement. Subsequently, the probe

2 is inserted into the meatus auditorius externus of the subject to face the eardrum to measure the temperature thereof. The probe 2 is oriented to the eardrum properly and then the probe 2 is taken out of the meatus auditorius externus. The liquid crystal display component 6 shows the maximum temperature measured here, so that the temperature of the eardrum, that is, the body temperature is displayed to allow the one to read the display as the body temperature of the subject.

Figs. 11 is a partially cut-out cross-sectional view showing the probe 2 of the radiation clinical thermometer shown in Fig.10.

The probe 2 is provided, on the top-end thereof, with a filter 7 which has transmission wavelength characteristics. The filter 7 is made from optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof.

A light guide tube 8 is a tube which is provided to efficiently converge the thermal radiation from the eardrum the temperature of which is to be measured, made of metal pipes such as copper, brass, or stainless steel, and the inner surface of which is a mirror-finished surface coated with gold (Au) to increase the reflectivity. The application of the coating, however, will not allow the inner surface of the light guide tube 8 to become a perfect reflector having a reflective index of 1.00 and thus cause the inner surface of the light guide

tube 8 to remain more or less radiative.

A light guide tube 9 is made from the same material as the light guide tube 8 with the inner surface treated in the same way as the light guide tube 8 and one end (on the side of the filter 7) sealed so that infrared radiation cannot come in from the temperature-measured object. In addition, the light guide tube 9 is provided close to the light guide tube 8 so as to keep approximately the same temperature as the light guide tube 8. The condition required for the light guide tube 9 is to reach approximately the same temperature as the light guide tube 8 but not always necessarily to be the same in material or inner surface condition.

A first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide tube 8, however, detects also the thermal radiation from the light guide tube 8 itself, whereas a second infrared sensor 11 detects the thermal radiation from the light guide tube 9 itself because the top-end of the light guide tube 9 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. A temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11.

The operation principle with the first and second infrared

sensors 10 and 11 is briefly explained here. If the light guide tube 8 and the first infrared sensor 10 are at the same temperature, the first infrared sensor 10 is allowed to apparently detect the infrared radiation only from the temperature-measured object. This is because the light guide tube 8 also gives off thermal radiation but has the same temperature as the infrared sensor 10, so that the thermal radiation from the light guide tube 8 is negligible when the difference in radiance and incidence at the infrared sensor 10 is taken into account. A difference in temperature between the light guide tube 8 and the first infrared sensor 10, however, develops a difference in thermal radiation between the light guide tube 8 and the first infrared sensor 10 to cause the first infrared sensor 10 to detect the thermal radiation from the temperature-measured object and the light guide tube 8 so that the thermal radiation from the light guide tube 8 is not negligible. Therefore the radiation clinical thermometer 1 of the present invention is provided with the second infrared sensor 11 to allow the second infrared sensor 11 to detect the infrared radiation from the light guide 9, which is held under the same temperature condition as the light guide tube 8, to reduce at an adequate proportion the output of the second infrared sensor 11 from the output of the first infrared sensor 10 which is affected by the temperature of the light guide tube 8 to detect the infrared radiation from the temperature-measured object, independent of the temperature effects of the

light guide tube 8.

Another example of the prior arts is not a clinical thermometer but a radiation thermometer which is disclosed in Japanese Laid-open Patent Publication No. Sho-61-66131.

This radiation thermometer is provided with a signal fiber which guides the infrared radiation from the temperature-measured object and corresponds to the light guide tube 8 of the radiation clinical thermometer proposed in Japanese Patent Application No. Hei-7-294117, and with a disturbance fiber corresponding to the light guide tube 9 to eliminate the effects of disturbance for measuring temperature.

There exists the problem, however, that providing two light guide tubes or fibers as conventionally done causes the diameter of the top-end for facing to the temperature-measured object, that is, the probe to become larger to accommodate two or more light guide tubes or fibers.

Especially for a radiation clinical thermometer which is inserted into the meatus auditorius externus to detect the infrared radiation from the eardrum, there exists a problem that a radiation clinical thermometer with a probe of a large diameter has difficulty in inserting the radiation clinical thermometer into the meatus auditorius externus to face to the eardrum of a child whose ear hole is small.

To overcome this problem, it may be considered to make the two light guide tubes etc. thinner, however, this causes the emission outlet of the light guide tubes to become smaller and

also the original view of the infrared sensor to become smaller due to the emission outlet. Additionally this causes the incident energy to decrease to lead to a decrease in sensitivity. Generally, making the view narrower tends to lead to decreasing the incident energy. And also a thin light guide tube etc. causes the number of reflections of infrared radiation inside the light guide tube to increase. Taking into account that energy is lost at every reflection, sensitivity is disadvantageously affected in this point.

DISCLOSURE OF THE INVENTION

The present invention is for purposes of the foregoing to provide a radiation clinical thermometer having a top-end, that is, a probe for facing the temperature-measured object made thinner without reducing sensitivity.

To achieve the forgoing purposes, the invention set forth in claim 1 is characterized in that the present invention is provided with a light guide means having an emission inlet and an emission outlet to guide the infrared radiation from the temperature-measured object, a first infrared sensor for detecting the infrared radiation from the light guide means, a temperature sensitive sensor which generates a reference temperature signal, a reference cavity which has approximately the same temperature condition as said light guide means and is sealed so as to shut out infrared radiation from outside, a second infrared sensor for detecting the infrared radiation from the reference cavity, a temperature computing means for

calculating temperature in accordance with the signals from said first infrared sensor and said second infrared sensor, and said temperature sensitive sensor, and a display unit for displaying temperature in accordance with the signal from the temperature computing means; and the probe is provided on the inside thereof with said light guide means and said reference cavity, at least either said light guide means or said reference cavity is tapered toward the emission inlet from said first or second infrared sensor.

The invention set forth in claim 2 is characterized in that, in the invention set forth in claim 1, said light guide means comprises a pipe and said reference cavity comprises a supporting member which supports said pipe.

Furthermore the invention set forth in claim 3 is characterized in that, in the invention set forth in claim 1, said light guide means comprises of a pipe and said reference cavity comprises of the outer wall of said pipe and the supporting member which supports said pipe.

Furthermore the invention set forth in claim 4 is characterized in that, in the invention set forth in claims 2 and 3, said supporting member comprises of a member of high thermal conductivity.

Furthermore the invention set forth in claim 5 is characterized in that, in the invention set forth in claim 4, said member of high thermal conductivity is made of aluminum.

Furthermore the invention set forth in claim 6 is

characterized in that, in the invention set forth in claims 2 and 3, said first infrared sensor and said second infrared sensor are arranged in parallel to each other across the center of said probe, and the emission inlet of said pipe are positioned approximately at the center of said probe and the emission outlet is positioned toward said first infrared sensor, whereby the pipe is positioned diagonally against the center line of said probe.

Furthermore the invention set forth in claim 7 is characterized in that, in the invention set forth in claims 2 and 3, said first infrared sensor is positioned on the center line of said probe and said pipe is positioned along said center line.

Furthermore the invention set forth in claim 8 is characterized in that, in the invention set forth in claim 1, said light guide means and said reference cavity are formed into the same member in one piece.

Furthermore the invention set forth in claim 9 is characterized in that, in the invention set forth in any one of claims 1 through 8, said temperature sensitive sensor is adhered to the bottom surface of said first infrared sensor or second infrared sensor by adhesive.

Furthermore the invention set forth in claim 10 is characterized in that, in the invention set forth in any one of claims 1 through 3, a window member for transmitting infrared radiation is fitted to said probe so as to seal the emission

inlet of said light guide means.

Furthermore the invention set forth in claim 11 is characterized in that, in the invention set forth in claims 2 and 3, a window member for transmitting infrared radiation is fitted to said pipe so as to seal the emission inlet of said light guide means.

Furthermore the invention set forth in claim 12 is characterized in that, in the invention set forth in claims 2 and 3, a window member for transmitting infrared radiation is fitted to said supporting member so as to seal the emission inlet of said light guide means.

According to the invention set forth in claim 1, the reference cavity is tapered toward the emission inlet of the light guide means from the second infrared sensor without reducing sensitivity, so that a radiation clinical thermometer which has a thin top-end, that is, a probe for facing temperature-measured objects can be provided. Furthermore, even in the case where the light guide means is tapered toward the emission inlet of the light guide means from the first infrared sensor side, a radiation clinical thermometer having a thin probe can be provided. Furthermore, compared with the conventional thermometer having two light guide tubes, less number of light guide tubes allows for producing a cheaper radiation clinical thermometer.

Furthermore, tapering off the probe to the top-end allows in turn the emission outlet to broaden, whereby the area of

the infrared sensor can be enlarged. An infrared sensor of a larger area allows for making the infrared sensor highly sensitive and thus providing a radiation clinical thermometer having a simple amplifier with less noise.

Furthermore the invention set forth in claim 2 has the effect that the reference cavity is formed only by the supporting member, whereby no space is available for allowing infrared radiation to come into the reference cavity from outside and thus infrared radiation from outside can be positively shut out.

Furthermore the invention set forth in claim 3 has the effect that the reference cavity is formed by the supporting member and the outer wall of the light guide tube, whereby the reference cavity easily reflects the temperature of the light guide tube.

Furthermore the invention set forth in claim 4 has the effect that the light guide means and the reference cavity can be easily held to approximately the same temperature. Additionally, in the case where a difference in temperature is developed between the light guide means and the infrared sensor, the effect that the light guide means and the infrared sensor reach an equilibrium state sooner is also given.

Furthermore the invention set forth in claim 5 has the effect that aluminum has a good thermal conductivity and also allows for forming a supporting member of a complicated shape by the aluminum die-casting.

Furthermore the invention set forth in claim 6 has the effect that a thinner probe can be made.

Furthermore the invention set forth in claim 7 has the effect that the center axis of the supporting member is the same as the center axis of the hole for inserting a pipe as the light guide tube, whereby the hole of the supporting member can be easily and accurately finished by cutting.

Furthermore, according to the invention set forth in claim 8, the pipe to be used as the light guide tube is not necessary and thereby costs can be saved.

Furthermore the invention set forth in claim 9 has the effect that the temperature of the sealed sensor can be measured with higher accuracy.

Furthermore the invention set forth in claim 10 has the effect that the filter can prevent water from coming into the probe.

Furthermore the invention set forth in claim 11 has the effect that the filter reaches the same temperature as the light guide tube, so that the body temperature can be measured more accurately.

Furthermore the invention set forth in claim 12 has the effect that, in the case the filter is fitted to the supporting member, the filter reaches approximately the same temperature as the supporting member (the light guide means by a light guide hole), so that the body temperature can be measured more accurately.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a partially cut-out cross-section view showing the probe of the first embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.2 is an explanatory block diagram showing the operation of the radiation clinical thermometer shown in Fig.1;

Fig.3 is a partially cut-out cross-section view showing the probe of the second embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.4 (a) is a cross-section view taken on line A-A' of Fig.3, Fig.4 (b) being a cross-section view taken on line B-B' of Fig.3, and Fig.4 (c) being a cross-section view taken on line C-C' of Fig.3;

Fig.5 is a partially cut-out cross-section view showing the probe of the third embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.6 is a partially cut-out cross-section view showing the probe of the fourth embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.7 is a partially cut-out cross-section view showing the probe of the fifth embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.8 is a partially cut-out cross-section view showing the probe of the sixth embodiment of the radiation clinical thermometer in accordance with the present invention;

Fig.9 is an explanatory view showing an example of the shape

of the reference cavity of the radiation clinical thermometer in accordance with the present invention;

Fig.10 is a front elevation view showing the radiation clinical thermometer suggested in Japanese Patent Application No. Hei-7-294117; and

Fig.11 is a partially cut-out cross-section view showing the probe 2 of the radiation clinical thermometer 1 shown in Fig.10.

PREFERRED EMBODIMENTS OF THE INVENTION

The present invention is described below in accordance with the drawings.

It is to be understood that the elevation front view of the radiation clinical thermometer in accordance with the present invention is almost the same as Fig.10, so that explanation on the following embodiments of the present invention is carried out referring to Fig.10.

Fig.1 is a partially cut-out cross-section view showing the probe of the first embodiment of the radiation clinical thermometer in accordance with the present invention. The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside with the light guide tube 15 and supporting member 16.

The light guide tube 15 is a pipe which is provided to efficiently converge the thermal radiation from the eardrum the temperature of which is to be measured, made of metal such as copper, brass, or stainless steel, and the inner surface of which is a mirror-finished surface coated with gold (Au)

to increase the reflectivity.

The light guide tube 15 is provided on the top-end thereof with the filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof. The light guide tube 15 is cut diagonally at the top-end thereof so that the filter 7 fitted to the top-end of the light guide tube 15 is positioned perpendicular to the center line of the probe.

The supporting member 16, which is a member for supporting the light guide tube 15 inside the probe 2, has the shape shown in Fig.1 to form the reference cavity 17 which serves as the light guide tube 9 in Fig.11. The supporting member 16 is a member of high thermal conductivity, the material of which is, for example, aluminum. The reference cavity 17 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. In addition, the reference cavity 17 is provided close to the light guide tube 15 to become approximately the same temperature as the light guide tube 15. The condition required for the reference cavity 17 is to reach approximately the same temperature as the light guide tube 15 but is not always necessarily the same in material or inner surface condition. Furthermore the reference cavity 17 is so

constructed as to be tapered toward the emission inlet 15a from the second infrared sensor 11.

A first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide tube 15, however, detects also the thermal radiation from the light guide tube 15 itself, whereas a second infrared sensor 11 detects the thermal radiation from the reference cavity 17 itself because the top-end of the reference cavity 17 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. A temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) for the adhesive 12a.

Furthermore the first infrared sensor 10 and the second infrared sensor 11 are arranged in parallel to each other across the center of the probe 2, and the emission inlet 15a of the light guide tube 15 is positioned approximately at the center of the probe 2 and the emission outlet 15b is positioned toward the first infrared sensor 10, whereby the light guide tube 15

is positioned diagonally against the center line of the probe 2.

Fig.2 is an explanatory block diagram showing the operation of the radiation clinical thermometer shown in Fig.1. It is to be understood that, in Fig.2, those parts that are the same as in Fig.1 are given by the same reference numbers.

The operation principle with the first and second infrared sensors 10 and 11 is briefly explained here. If the light guide tube 15 and the first infrared sensor 10 are at the same temperature, the first infrared sensor 10 is allowed to apparently detect the infrared radiation only from the temperature-measured object. This is because the light guide tube 15 also gives off thermal radiation but has the same temperature as the infrared sensor 10, so that the thermal radiation from the light guide tube 15 is negligible when the difference in radiance and incidence at the infrared sensor 10 is taken into account. A difference in temperature between the light guide tube 15 and the first infrared sensor 10, however, develops a difference in thermal radiation between the light guide tube 15 and the first infrared sensor 10 to cause the first infrared sensor 10 to detect the thermal radiation from the temperature-measured object and the light guide tube 15 so that the thermal radiation from the light guide tube 15 is not negligible.

Therefore the radiation clinical thermometer of the present invention is provided with the second infrared sensor

11 to detect the infrared radiation from the reference cavity 17, which is held under the same temperature condition as the light guide tube 15, to reduce at an adequate proportion the output of the second infrared sensor 11 from the output of the first infrared sensor 10 which is affected by the temperature of the light guide tube 15 to detect the infrared radiation from the temperature-measured object, independent of the temperature effects of the light guide tube 15. The temperature computing means 13 calculates the temperature of the temperature-measured object in accordance with the outputs from the first infrared sensor 10, the second infrared sensor 11, and the temperature sensitive sensor 12, and displays the temperature on the display unit 14.

Fig.3 is a partially cut-out cross-section view showing the probe of the second embodiment of the radiation clinical thermometer in accordance with the present invention.

The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside with the light guide tube 18 and supporting member 19.

The light guide tube 18 is a pipe which is provided to efficiently converge the thermal radiation from the eardrum the temperature of which is to be measured, made of metal such as copper, brass, or stainless steel, and the inner surface of which is a mirror-finished surface coated with gold (Au) to increase the reflectivity.

The probe 2 is provided on the top-end thereof with the

filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof. In this embodiment, the filter 7 is provided not on the top-end of the light guide tube 18 but on the top-end of the probe 2, so that the top-end of the light guide tube 18 is not required to be cut diagonally.

The supporting member 19, which is a member for supporting the light guide tube 18 inside the probe 2, has the shape shown in Fig.3 to form the reference cavity 20 which serves as the light guide tube 9 in Fig.11. The supporting member 19 is a member of high thermal conductivity, the material of which is, for example, aluminum. The reference cavity 20 of this embodiment comprises the supporting member 19 and the outer wall of the light guide tube 18, and the reference cavity 20 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. Additionally, the outer wall of the light guide tube 18 constitutes a part of the reference cavity 20, so that the inner wall of the reference cavity 20 approximates the same temperature as the inner wall of the light guide tube 18. The condition required for the reference cavity 20 is to reach almost the same temperature as the light guide tube 18 but is not always necessarily the same in material or

inner surface condition. Furthermore the reference cavity 20 is so constructed as to be tapered toward the filter 7 side from the second infrared sensor 11 side.

The first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide tube 18, however, detects also the thermal radiation from the light guide tube 18 itself, whereas the second infrared sensor 11 detects also the thermal radiation from the reference cavity 20 itself because the top-end of the reference cavity 20 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. The temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) as the adhesive 12a.

Furthermore the first infrared sensor 10 and the second infrared sensor 11 are arranged in parallel to each other across the center of the probe 2, and the emission inlet 18a of the light guide tube 18 is positioned approximately at the center of the probe 2 and the emission outlet 18b is positioned toward

the first infrared sensor 10, whereby the light guide tube 18 is positioned diagonally against the center line of the probe 2.

Furthermore, in this embodiment, the first infrared sensor 10 and the second infrared sensor 11 are sealed with cover 21 which adheres the window member with low melting-point glass to receive infrared radiation through the windows 22 and 23. The windows 22 and 23 are made from barium fluoride (BaF_2) or silicon (Si) with anti-reflection coating (AR coating). Nitrogen gas is sealed in the room enclosed with the cover 21 to prevent the first infrared sensor 10 and the second infrared sensor 11 from being deteriorated.

It is to be understood that the operation of the radiation clinical thermometer of this embodiment is the same as the first embodiment shown in Fig.1 and, for this reason, an explanation is omitted here.

Fig.4 (a) is a cross-section view showing the radiation clinical thermometer, cut in a direction different from that of Fig.3; (a) is a cross-section view taken on line A-A' of Fig.3; . (b) is a cross-section view taken on line B-B' of Fig.3; and (c) is a cross-section view taken on line C-C' of Fig.3. In each cross-section view, only the light guide tube 18, the supporting member 19, and the reference cavity 20 are illustrated.

It is to be clearly understood that the outer wall of the light guide tube 18 constitutes a part of the inner wall of

the reference cavity 20 and the reference cavity 20 is tapered toward the filter 7 from the first infrared sensor 10.

Fig.5 is a partially cut-out cross-section view showing the probe of the third embodiment of the radiation clinical thermometer in accordance with the present invention.The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside the same with the light guide tube 24 and supporting member 25.

The light guide tube 24 is a pipe which is provided to efficiently converge the thermal radiation from the eardrum the temperature of which is to be measured, made of metal such as copper, brass, or stainless steel, and the inner surface of which is a mirror-finished surface coated with gold (Au) to increase the reflectivity.

The probe 2 is provided on the top-end thereof with the filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has the infrared-wavelength selective transmission and dust proof function.

The supporting member 25, which is a member for supporting the light guide tube 24 inside the probe 2, has the shape shown in Fig.5 to form the reference cavity 26 which serves as the light guide tube 9 in Fig.11. The supporting member 25 is a member of high thermal conductivity, the material of which is,

for example, aluminum. The reference cavity 26 of this embodiment comprises the supporting member 25 and the outer wall of the light guide tube 24, and the reference cavity 26 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. Additionally the outer wall of the light guide tube 24 constitutes a part of the reference cavity 26, so that the inner wall of the reference cavity 26 is to approximate the same temperature as the inner wall of the light guide tube 24. The condition required for the reference cavity 26 is to reach almost the same temperature as the light guide tube 24 but is not always necessarily the same in material or inner surface condition. Furthermore the reference cavity 26 is so constructed as to be tapered toward the filter 7 side from the second infrared sensor 11 side.

This embodiment, as is understood by comparing Fig.3 with Fig.5, is characterized in that the light guide tube 24 is provided perpendicular to the filter 7 and the first infrared sensor 10. That is, the first infrared sensor 10 is positioned on the center line of the probe 2 and the light guide tube 24 is positioned along the center line of the probe 2, whereby the diameter of the probe 2 is made a little larger compared with the embodiment shown in Fig.3, however, the center axis of the supporting member 25 is the same as the center axis of the hole for inserting a pipe as the light guide tube 24, whereby the hole of the supporting member 25 can be easily and

accurately finished by cutting.

The first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide tube 24, however, detects also the thermal radiation from the light guide tube 24 itself, whereas the second infrared sensor 11 detects the thermal radiation from the reference cavity 26 itself because the top-end of the reference cavity 26 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. The temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) for the adhesive 12a.

Furthermore, in this embodiment, the first infrared sensor 10 and the second infrared sensor 11 are sealed with the cover 21 which adheres the window member with low melting-point glass to receive infrared radiation through the windows 22 and 23. The windows 22 and 23 are made from barium fluoride (BaF_2) or silicon (Si) with anti-reflection coating (AR coating). Nitrogen gas is sealed in the room enclosed with the cover 21

to prevent the first infrared sensor 10 and the second infrared sensor 11 from being deteriorated.

It is to be understood that the operation of the radiation clinical thermometer of this embodiment is the same as the first embodiment shown in Fig.1 and, for this reason, an explanation is omitted here.

Fig.6 is a partially cut-out cross-section view showing the probe of the fourth embodiment of the radiation clinical thermometer in accordance with the present invention;

The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside with the light guide tube 24 and supporting member 27.

The light guide tube 24 is a pipe which is provided to efficiently converge the thermal radiation from the eardrum the temperature of which is to be measured, made of metal such as copper, brass, or stainless steel, and the inner surface of which is a mirror-finished surface coated with gold (Au) to increase the reflectivity.

The probe 2 is provided on the top-end thereof with the filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof.

The supporting member 27, which is a member for supporting

the light guide tube 24 inside the probe 2, has the shape shown in Fig.6 to form the reference cavity 28 which serves as the light guide tube 9 in Fig.11. The supporting member 27 is a member of high thermal conductivity, the material of which is, for example, aluminum. The reference cavity 28 of this embodiment comprises the supporting member 27 and the outer wall of the light guide tube 24, and the reference cavity 28 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. Additionally, the outer wall of the light guide tube 24 constitutes a part of the reference cavity 28, so that the inner wall of the reference cavity 28 approximates the same temperature as the inner wall of the light guide tube 24. The condition required for the reference cavity 28 is to reach almost the same temperature as the light guide tube 24 but is not always necessarily the same in material or inner surface condition. Furthermore the reference cavity 28 is so constructed as to be tapered toward the filter 7 from the second infrared sensor 11.

The first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide tube 24, however, detects also the thermal radiation from the light guide tube 24 itself, whereas the second infrared sensor 11 detects the thermal radiation from the reference cavity 28 itself because the top-end of the reference cavity 28 is sealed. In addition, the

second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. The temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) as the adhesive 12a.

Furthermore, in this embodiment, unlikewise the embodiment shown in Fig.5, the first infrared sensor 10 and the second infrared sensor 11 are not built in one piece. That is, the first infrared sensor 10 is covered with a cover 29 having a window 30; the second infrared sensor 11 is covered with a cover 31 having a window 32; the covers 29 and 31 are sealed with silicone of high thermal conductivity; the windows 30 and 32 are made from barium fluoride (BaF_2) or silicon (Si) with anti-reflection coating (AR coating); and nitrogen gas is sealed in the room enclosed with the covers 29 and 31 to prevent the first infrared sensor 10 and the second infrared sensor 11 from being deteriorated. As long as the first infrared sensor 10 and the second infrared sensor 11 have approximately the same temperature, the first infrared sensor 10 and the second infrared sensor 11 are not necessarily made in one piece

but may be made separate, and also the angles of the first infrared sensor 10 and the second infrared sensor 11 may be different from each other.

It is to be understood that the operation of the radiation clinical thermometer of this embodiment is the same as the first embodiment shown in Fig.1 and, therefore, an explanation is omitted here.

Fig.7 is a partially cut-out cross-section view showing the probe of the fifth embodiment of the radiation clinical thermometer in accordance with the present invention;

The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside with the supporting member 33.

The supporting member 33 is provided on the top-end thereof with the filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof.

The supporting member 33 has the shape shown in Fig.7 so as to form the light guide hole 34 which serves as the light guide tube 8 shown in Fig.11 and so as to form the reference cavity 35 which serves as the light guide tube 9 shown in Fig.11. The material of the supporting member 33 is, for example, aluminum or plastic and, in the case of plastic, one of high

thermal conductivity may be preferably selected. The inner surface of the light guide hole 34 is a mirror-finished surface coated with gold (Au) to increase the reflectivity. To treat the surface with gold, nickel may be coated before gold to the original surface, or gold may be directly deposited on the plastic surface. The reference cavity 35 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. Additionally, the reference cavity 35 is provided close to the light guide hole 34 so as to have approximately the same temperature as the light guide hole 34. The condition required for the reference cavity 35 is to reach approximately the same temperature as the light guide hole 34 but is not always necessarily the same in material or inner surface condition. Furthermore the reference cavity 35 is so constructed as to be tapered toward the filter 7 from the second infrared sensor 11.

The first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide hole 34, however, detects also the thermal radiation from the light guide hole 34 itself, whereas the second infrared sensor 11 detects the thermal radiation from the reference cavity 35 itself because the top-end of the reference cavity 35 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same

temperature as the first infrared sensor 10. The temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) as the adhesive 12a.

It is to be understood that the operation of the radiation clinical thermometer of this embodiment is the same as the first embodiment shown in Fig.1 and, therefore, an explanation is omitted here.

Fig.8 is a partially cut-out cross-section view showing the probe of the sixth embodiment of the radiation clinical thermometer in accordance with the present invention;

The material of the probe 2 is, for example, ABS resin, and the probe 2 is provided inside with the supporting member 36.

The supporting member 36 is provided on the top-end thereof with the filter 7 having transmission wavelength characteristics. The filter 7, a window member for transmitting infrared radiation, is formed by optical crystal such as silicon (Si) or barium fluoride (BaF_2), or a polymer such as polyethylene and has a function of infrared-wavelength selective transmission and dust proof.

The supporting member 36 has the shape shown in Fig.8 so as to form the light guide hole 37 as the a light guide means which serves as the light guide tube 8 shown in Fig.11 and so as to form the reference cavity 38 which serves as the light guide tube 9 shown in Fig.11. The material of the supporting member 36 is, for example, aluminum or plastic and, in the case of plastic, one of high thermal conductivity may be preferably selected. The inner surface of the light guide hole 37 is a mirror-finished surface coated with gold (Au) to increase the reflectivity. To treat the surface with gold, nickel may be coated before gold to the original surface, or gold may be directly deposited on the plastic surface. The reference cavity 38 is sealed at the one end thereof (on the side of filter 7) so as to prevent infrared radiation from coming in from the temperature-measured object. Additionally, the reference cavity 38 is provided close to the light guide hole 37 so as to have approximately the same temperature as the light guide hole 37. The condition required for the reference cavity 38 is to reach approximately the same temperature as the light guide hole 37 but is not always necessarily the same in material or inner surface condition. Furthermore the reference cavity 38 is so constructed as to be tapered toward the filter 7 side from the second infrared sensor 11 side.

Additionally, in this embodiment, the light guide hole 37 is so constructed as to be tapered toward the filter 7 from the first infrared sensor 10. It may be considered reasonable

that a small emission inlet for the infrared radiation from the temperature-measured object causes the incident energy received by the first infrared sensor 10 to decrease, however, the incident energy is never made small according to this embodiment. This is explained below.

When the light guide hole 37 becomes smaller, the infrared radiation from the temperature-measured object reaches the infrared sensor 10 by reflecting more frequently inside the light guide hole 37, and thus the incident energy is attenuated. In this embodiment, however, the reflective coefficient of the light guide hole 37 is made extremely close to 1, whereby an increase in the number of reflection inside the light guide hole 37 may not cause attenuation due to reflection to develop. Additionally, in the case where the inner surface of the light guide hole 37 is a perfect reflector, the incident energy to be received by the first infrared sensor depends on the size of the emission outlet of the light guide hole 37 which determines the view of the infrared sensor. Generally narrowing the view tends to result in a decrease in the incident energy. As shown in Fig.8, the incident energy never decreases unless the emission outlet of the light guide hole 37 is made smaller, and thus sensitivity is never deteriorated.

Turning to Fig.8, the first infrared sensor 10 is a sensor which detects the infrared radiation, emitted from the temperature-measured object, converged by the light guide hole 37, however, detects also the thermal radiation from the light

guide hole 37 itself, whereas the second infrared sensor 11 detects the thermal radiation from the reference cavity 38 itself because the top-end of the reference cavity 38 is sealed. In addition, the second infrared sensor 11 is provided close to the first infrared sensor 10 so as to have approximately the same temperature as the first infrared sensor 10. The temperature sensitive sensor 12 is a sensor which allows for measuring the temperature of the first infrared sensor 10 and the second infrared sensor 11. Therefore the temperature sensitive sensor 12 is preferably fixed to the bottom surface of the first infrared sensor 10 or the second infrared sensor 11, for example, by adhesive 12a. An adhesive of high thermal conductivity may be preferably selected (for example, silicone of high thermal conductivity) as the adhesive 12a.

It is to be understood that the operation of the radiation clinical thermometer of this embodiment is the same as the first embodiment shown in Fig.1 and, therefore, an explanation is omitted here.

In this embodiment, in the case where the supporting member 36 is provided with the light guide hole 37, the light guide hole 37 is so constructed as to be tapered toward the filter 7 side from the first infrared sensor 10 side, to which the present invention is not limited, in the case where a light guide tube is used, the light guide tube may be so constructed as to be tapered toward the filter 7 side from the first infrared sensor 10 side. In this case, the light guide tube may be made

from metal such as copper, brass, or stainless steel, and also from plastic as other material by depositing gold on to a plastic film having mirror surface and then forming a cone of the film to use the cone as the light guide tube.

Furthermore, in this embodiment, both the reference cavity 38 and the light guide hole 37 are so constructed as to be tapered toward the filter 7 side from the first infrared sensor 10 or the second infrared sensor 11, to which the present invention is not limited, however, only the light guide hole 37 may be so constructed as to be tapered toward the filter 7 from the first infrared sensor 10.

Each embodiment explained above is an example wherein the reference cavity of the supporting member is formed by die-casting, to which the present invention is not limited, the reference cavity may be formed by cutting. In this case the reference cavity is not always necessarily to be tapered continuously smooth but it is sufficient that the area of the emission inlet is smaller than the area of the emission outlet. For example, as shown in Fig.9, the supporting member 39 may be tapered stepwise when the reference cavity 40 is formed. Even in this case, it still remains unchanged that the reference cavity 40 is so constructed as to be tapered off toward the emission inlet of the light guide means from the second infrared sensor side.

TECHNICAL AVAILABILITY OF THE INVENTION

The present invention is disclosed for a radiation clinical

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WHAT IS CLAIMED IS:

1. A radiation clinical thermometer comprising a light guide means which is provided with an emission inlet and an emission outlet to guide the infrared radiation from the temperature-measured object; a first infrared sensor for detecting the infrared radiation from the light guide means; a temperature sensitive sensor which generates a reference temperature signal; a reference cavity which indicates approximately the same temperature condition as said light guide means and is sealed so as to shut out infrared radiation from outside, a second infrared sensor for detecting the infrared radiation from the reference cavity; a temperature computing means for calculating temperature in accordance with the signals from said first infrared sensor, said second infrared sensor, and said temperature sensitive sensor; and a display unit for displaying temperature in accordance with the signal from the temperature computing means; wherein the probe is provided on the inside thereof with said light guide means and said reference cavity, at least either said light guide means or said reference cavity is tapered off toward the emission inlet from said first or second infrared sensor side.

2. The radiation clinical thermometer set forth in claim 1 characterized in that said light guide means comprises a pipe and said reference cavity comprises a supporting member which supports said pipe.

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3. The radiation clinical thermometer set forth in claim 1 characterized in that said light guide means comprises a pipe and said reference cavity comprises the outer wall of said pipe and the supporting member which supports said pipe.

4. The radiation clinical thermometer set forth in claim 2 or 3 characterized in that said supporting member comprises a member of high thermal conductivity.

5. The radiation clinical thermometer set forth in claim 4 characterized in that said member of high thermal conductivity is made of aluminum.

6. The radiation clinical thermometer set forth in claim 2 or 3 characterized in that said first infrared sensor and said second infrared sensor are arranged in parallel to each other across the center of said probe, and the emission inlet of said pipe are positioned approximately at the center of said probe and the emission outlet is positioned toward said first infrared sensor, whereby the pipe is positioned diagonally against the center line of said probe.

7. The radiation clinical thermometer set forth in claim 2 or 3 characterized in that said first infrared sensor is positioned on the center line of said probe and said pipe is positioned along said center line.

8. The radiation clinical thermometer set forth in claim 1 characterized in that said light guide means and said reference cavity are formed into the same member in one piece.

9. The radiation clinical thermometer set forth in any one

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of claims 1 to 8 characterized in that said temperature sensitive sensor is adhered to the bottom surface of said first infrared sensor or second infrared sensor by adhesive.

10. The radiation clinical thermometer set forth in any one of claims 1 to 3 characterized in that a window member for transmitting infrared radiation is fitted to said probe so as to seal the emission inlet of said light guide means.

11. The radiation clinical thermometer set forth in claim 2 or 3 characterized in that a window member for transmitting infrared radiation is fitted to said pipe so as to seal the emission inlet of said light guide means.

12. The radiation clinical thermometer set forth in claim 2 or 3 characterized in that a window member for transmitting infrared radiation is fitted to said supporting member so as to seal the emission inlet of said light guide means.

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