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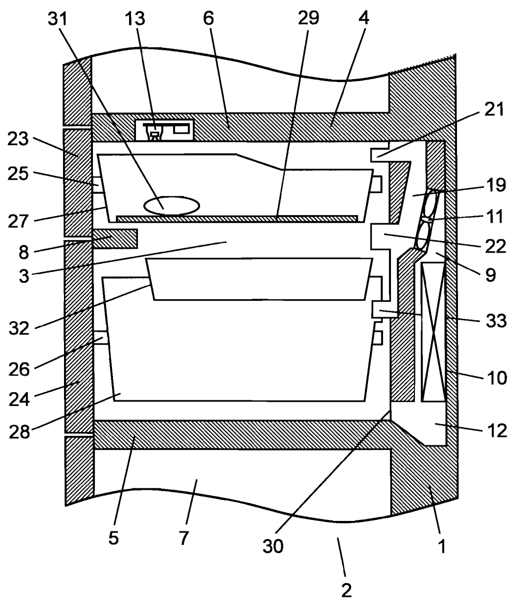
# (54) REFRIGERATOR

(57) A refrigerator includes a heat-insulating box formed of multiple heat-insulating divisions, heat-insulating partitions for partitioning the heat-insulating box, a storage compartment partitioned by the heat insulating partitions, an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment, and an infrared ray condensing member provided at inner side of the storage room than the infrared sensor. At least an inside wall face of the infrared ray condensing member has greater heat retainable force.

FIG. 1

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## Description

Technical Field

**[0001]** The present invention relates to refrigerators using infrared sensors.

Background Art

**[0002]** Refrigerators with larger capacities have been demanded from the market in recent years. To meet this demand, useless spaces in refrigerators are reduced for improving the volumetric efficiency. On top of that, various layouts in refrigerators are available for enhancing ease of use.

**[0003]** A conventional refrigerator employs, e.g. thermistors, for measuring an air temperature therein. When a user puts hot food in the refrigerator, a multitude of thermistors placed in the refrigerator measures the air temperature warmed by the hot food, whereby a cooling amount can be adjusted. However, this refrigerator actually does not measure the temperature of the food at first hand, so that it is not aware of whether or not the food is cooled enough. Since the food can be cooled down to a target temperature by cooling the surrounding air, it takes time for the food to be cooled down to the target temperature. To overcome this problem, a refrigerator is equipped with an infrared sensor in order to sense an actual temperature of food, thereby carrying out a cooling operation. This kind of refrigerator is disclosed in, e.g. Patent Literature 1.

**[0004]** The conventional refrigerator discussed above is described hereinafter with reference to Figs. 10 and 11. Fig. 10 shows a lateral sectional view of the refrigerator disclosed in Patent Literature 1. Fig. 11 shows an enlarged view of a part of Fig. 10. As shown in Fig. 10, refrigerator 201 formed of heat-insulating box uses its interior space as a storage space, in which refrigerator compartment 202, vegetable compartment 203, and freezer compartment 204 are placed independently in this order from top to bottom. Between refrigerator compartment 202 and vegetable compartment 203, temperature changeable compartment 205 and an icemaker compartment (not shown) are placed side-by-side with a heat-insulating partition between them. Each compartment is equipped with a door at its front opening to be opened or closed.

**[0005]** Behind vegetable compartment 203, there are freezer compartment 204, temperature changeable compartment 205, cooling device 206 including an icemaker compartment for cooling the freezer, and cooling fan 207 for circulating cool air produced by cooling device 206 in the storage compartments. In front of cooling device 206 for freezing, there are cooling device 208 for refrigerating and cooling fan (not shown) for cooling refrigerator compartment 202 and vegetable compartment 204.

**[0006]** Refrigerants are applied to cooling devices 206 and 208 simultaneously or alternatively by driving compressor 209, placed in a machine compartment located at the lower section of the refrigerator, as well as by controlling a switching valve of flow-path of the refrigerants. The cool air is blown to the compartments kept at a freezing temperature zone or a refrigerating temperature zone by cooling fan 207 and the fan for refrigerating respectively, so that those compartments are cooled down to given temperatures. The cool air discharged at a low temperature from cooling device 206 for the freezer is distributed by fan 207 into freezer compartment 204, an icemaker compartment, and temperature changeable compartment 205 through respective ducts for cooling those compartments.

**[0007]** Temperature changeable compartment 205 is equipped with infrared sensor 212 at recess 213 formed on the ceiling of compartment 205. At the opening of recess 213, shutter mechanism 214 is placed. A sensing of opening the door of compartment 205 prompts shutter mechanism 214 to close the opening of recess 213. A sensing of closing the door of compartment 205 prompts shutter mechanism 214 to open the opening of recess 213 so that cool air is blown from blow-off port 210 into compartment 205. Food 211 placed in compartment 205 is cooled by this cool air, and infrared sensor 212 senses a temperature of food 211. On top of that, a refrigerating cycle is operated and a cool-air damper placed near blow-off port 211 is opened or closed such that an amount of cool air introduced in compartment 205 is adjusted to control the temperature of food 211 to be at a given temperature.

**[0008]** As discussed above, infrared sensor 212 senses a surface temperature of target food 211, whereby the cooling operation is efficiently controlled, i.e. the cooling operation is done in a necessary amount only when it is needed.

**[0009]** However, when a user puts hot food in compartment 205 by opening the door of compartment 205, the foregoing conventional structure needs to sense the opening of the door of compartment 205 for closing the opening of the recess with the shutter mechanism in order to prevent warm air from stagnating in compartment 205 because fresh air flows into compartment 205 by opening the door. The shutter mechanism thus prevents the warm air from entering the recess. Temperature changeable compartment 205 thus needs a switch for sensing opening/closing of the door, and the shutter mechanism working with the switch. In particular, a complicated movable section that opens/closes the shutter mechanism following the opening/closing of the door will malfunction in the event that some foreign substance, dew or frost attached to around the shutter mechanism. The shutter mechanism including this complicated movable section is mounted to the refrigerator of which average service life is as long as 10 years. The frequent opening/closing of the door increases the possibility of malfunction of the shutter mechanism, so that the reliability of the refrigerator can be lowered.

**[0010]** Use of the complicated structure as discussed above not only increases the possibility of failures but also requires electric power to operate the motor and the controller. It is thus difficult to implement an energy-saving mode with the infrared sensor employed.

**[0011]** A thermistor has been used for sensing a temperature of an icemaker tray placed in the freezer compartment. For instance, in a case where a temperature of the water held in the icemaker tray is measured, the thermistor placed under the tray measures the temperature indirectly, thereby determining whether or not the water in the tray is frozen while a cooling amount to the freezer compartment is adjusted. However, this kind of refrigerator does not directly measure the temperature of the water held in the tray, so that a user cannot actually realize whether or not the water has been frozen. The cooling operation thus needs to be kept until the ice is made, i.e. the cooling operation is kept until the thermistor senses a target temperature. It thus takes time for completing the ice-making.

**[0012]** To overcome the foregoing drawback, an infrared sensor is placed jus above the icemaker tray, so that the infrared sensor senses heat energy of the water held in the tray as an amount of infrared ray radiated from the water. The actual temperature of the water can be thus sensed, and the cooling operation is implemented based on this actual temperature (refer to, e.g. Patent Literature 2).

**[0013]** The refrigerator disclosed in Patent Literature 2 is described hereinafter with reference to Figs. 12 and 13. Fig. 12 shows a lateral sectional view of the conventional refrigerator disclosed in Patent Literature 2, and Fig. 13 shows an enlarged view of a part of the conventional refrigerator.

**[0014]** As shown in Figs. 12 and 13, the refrigerator (not shown) includes a freezer compartment (not shown) in which icemaker compartment 301 is provided. Icemaker compartment 301 has door 302 for taking out food or ice cubes. Behind icemaker compartment 301, there is fan grille 303 which blows cool air from its blow-off port 304 into icemaker compartment 301, so that water 306 in icemaker tray 305 placed in icemaker compartment 301 is cooled.

**[0015]** Icemaker compartment 301 is equipped with heat insulator 307 at its ceiling, and infrared sensing device 308 is mounted to heat insulator 307. Infrared sensor 309 senses an amount of infrared ray through light guiding section 311 of cylindrical holder 310 covering infrared sensor 309. The infrared ray is radiated from the water held in icemaker tray 305.

**[0016]** Infrared sensor 309 senses a change in heat energy occurring when water 306 in tray 305 changes into ice, thereby determining the completion of ice making, and then the cooling operation is ended before the completion of ice making is displayed.

**[0017]** In the foregoing conventional structure, infrared sensing device 308 is provided in icemaker compartment 301, so that electrostatic discharge (ESD) is produced by static electricity charged in a human body or static electricity is produced by rubbing a cleaning towel against the inner faces of icemaker compartment 301. In the event that the discharged energy of the static electricity is applied to infrared sensing device 308, infrared sensor 309 malfunctions or breaks down, or an element of sensor 309 per se is damaged. The sensing function of infrared sensor 309 thus cannot work at all, which lowers the quality of the refrigerator.

Patent Literature 1: Unexamined Japanese Patent Application Publication No. 2007 - 212053
Patent Literature 2: Unexamined Japanese Patent Application Publication No. 2006 - 308504

## Disclosure of Invention

**[0018]** The refrigerator of the present invention comprises the following structural elements:

a heat-insulating box formed of multiple heat-insulating divisions;
a heat-insulating partition for partitioning the heat-insulating box;
a storage compartment partitioned by the heat-insulating partition;
an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment; and
an infrared ray condensing member provided at inner side of the storage compartment than the infrared sensor, and at least an inside wall of the infrared ray condensing member has greater heat retainable force.

**[0019]** In the structure discussed above, the infrared ray condensing member, of which inner wall has greater heat retainable force, is positioned within the visual field of the infrared sensor, so that the variation in temperature within visual field of the infrared sensor can be restricted. As a result, the properties of the infrared ray condensing member, i.e. the properties of following the temperature variation caused by disturbance, can be mitigated, and the temperature stability in the visual field of the infrared sensor can be improved. The simple structure discussed above can prevent the sensing accuracy from degrading. This degradation may be caused by disturbance, e.g. opening/closing the door or putting hot food into the compartment, and this disturbance varies an ambient temperature of the temperature sensing section of the infrared sensor. The sensing accuracy of the infrared sensor can be thus improved.

## Brief Description of Drawings

**[0020]**

Fig. 1 shows a lateral sectional view of an essential part of a refrigerator in accordance with a first embodiment of the present invention.

Fig. 2A shows a lateral sectional view of a mounting section of an infrared sensor of the refrigerator shown in Fig. 1.

Fig. 2B shows an enlarged view of an essential part of the mounting section shown in Fig. 2A.

Fig. 3 shows a comparison among temperatures of infrared converging sections in the event of opening the door of the refrigerator in accordance with the first embodiment.

Fig. 4 shows a lateral sectional view of an essential part of a refrigerator in accordance with a second embodiment of the present invention.

Fig. 5A shows a lateral sectional view of an essential part of a refrigerator in accordance with a third embodiment of the present invention.

Fig. 5B shows a plan view of a freezer compartment of the refrigerator shown in Fig. 5A.

Fig. 6 shows a lateral sectional view of an essential part of a refrigerator in accordance with a fourth embodiment of the present invention.

Fig. 7 shows a lateral sectional view of a mounting section of an infrared sensor of the refrigerator in accordance with the fourth embodiment.

Fig. 8 shows an enlarged view of section A shown in Fig. 7.

Fig. 9 shows a plan view of the mounting section of the infrared sensor of the refrigerator in accordance with the fourth embodiment, this plan view is viewed along direction B, i.e. from just above the mounting section, shown in Fig. 8.

Fig. 10 shows a lateral sectional view of a conventional refrigerator.

Fig. 11 shows an enlarged lateral sectional view of a part of the refrigerator shown in Fig. 10.

Fig. 12 shows a lateral sectional view of a conventional refrigerator.

Fig. 13 shows an enlarged lateral sectional view of a part of the refrigerator shown in Fig. 12.

Description of Reference Sings

**[0021]**

| | |
|---|---|
| 1, 101 | heat insulating box |
| 2, 102 | refrigerator |
| 3, 103 | freezer compartment (storage compartment) |
| 4, 104 | upper heat insulating partition |
| 5, 105 | lower heat insulating partition |
| 6, 106 | refrigerator compartment (storage compartment) |
| 7, 107 | vegetable compartment (storage compartment) |
| 8, 108 | partition |
| 9, 109 | cool air generating compartment |
| 10, 110 | evaporator |
| 11, 111 | blower |
| 12, 112 | defrosting heater |
| 13, 113 | infrared sensor |
| 13a | first infrared sensor |
| 13b | second infrared sensor |
| 21, 33, 121, 122 | cool air blow-off port |
| 21a | first cool-air blow-off port |
| 21h | second cool-air blow-off port |
| 22, 133 | cool air blow-off port |
| 23, 24, 123, 124 | door |
| 25, 26, 125, 126 | frame |
| 27, 127 | upper basket |
| 28, 128 | lower basket |
| 29, 129 | cool storage member |
| 30, 130 | cool air sucking port |
| 31, 131 | food |
| 32, 132 | middle basket |
| 40, 140 | infrared receptor |
| 40a | infrared receptor placement face |
| 41, 141 | board |
| 42, 142 | thermistor |
| 42a | thermistor placement face |
| 43, 143 | infrared element |
| 44, 144 | connector |
| 45, 145 | wiring |
| 46, 146 | wire |
| 47, 147 | infrared sensor mounting case |
| 48, 148 | infrared ray condensing member |
| 48a, 148a | leading end-face of infrared ray condensing member |
| 48b | tailing end-face of infrared ray condensing member |
| 49, 149 | recess |
| 49a | entrance face of recess |
| 50, 150 | through port |
| 50a | inner wall face of through port |
| 50b | leading end of through port |
| 51, 151 | condensing opening |
| 147a | outer face, confronting the freezer compartment, of the infrared sensor mounting case |
| 152 | protrusion |
| 152a | protrusion opening |
| 153 | slope |

Preferred Embodiments for Carrying out the Invention

**[0022]** The refrigerator of the present invention comprises the following structural elements:

a heat-insulating box formed of multiple heat-insulating divisions;
heat-insulating partitions for partitioning the heat-insulating box;
storage compartments partitioned by the heat-insulating partitions;
an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiat-

ed from an object stored in the storage compartment; and

an infrared ray condensing member provided at inner side of the storage room than the infrared sensor, and at least an inside wall face of the infrared ray condensing member has greater heat retainable force.

**[0023]** The structure discussed above restricts the variation in temperature within visual field of the infrared sensor. For this purpose, the infrared ray condensing member, of which inner wall has the greater heat retainable force, is positioned within the visual field of the infrared sensor. As a result, the properties of the infrared ray condensing member, i.e. the properties of following the temperature variation caused by disturbance, can be mitigated, and the temperature stability in the visual field of the infrared sensor can be improved. The simple structure discussed above can prevent the sensing accuracy from degrading. This degradation may be caused by disturbance, e.g. opening/closing the door or putting hot food into the compartment, and this disturbance varies an ambient temperature of the temperature sensing section of the infrared sensor. The sensing accuracy of the infrared sensor can be thus improved.

**[0024]** The refrigerator of the present invention includes an infrared sensor mounting case for accommodating the infrared sensor, and the case has a condensing opening shaped in an identical form to the lateral face of the infrared ray condensing member and extending through the case. The case is buried in a recess formed at the heat insulating partition. The infrared ray condensing member is surrounded at its lateral face by resin member having a greater heat capacity. The heat capacity of the condensing member can be thus increased, and a smaller range of temperature change can be expected in the condensing member. Changes in ambient temperature of the infrared sensor can be thus further reduced. As a result, the sensing accuracy of the infrared sensor can be much improved.

**[0025]** The infrared ray condensing member of the refrigerator is buried in the recess such that the leading end-face of the condensing member is flush with an entrance face of the recess. This structure allows warm air, introduced by opening the door, to flow along only the leading end-face of the infrared ray condensing member. The flush face free from inequality allows preventing warm air introduced by opening the door or evaporated from food from stagnating. As a result, a smaller range of temperature change can be expected when the door is open, so that erroneous sensing by the infrared sensor due to sharp changes in ambient temperature can be prevented. The stability of sensing accuracy of the infrared sensor can be thus improved.

**[0026]** The infrared ray condensing member of the refrigerator of the present invention is made of metal of which chief ingredient is aluminum. Use of the metal chiefly made of aluminum excellent in heat conductivity allows quicker heat responsiveness even when warm air is introduced by opening the door. The sensing accuracy of the infrared sensor can be thus improved.

**[0027]** The infrared ray condensing member of the refrigerator is formed of resin and powder oxide, and a content of the powder oxide is 85% or more. The condensing member thus has electric insulating properties. This structure allows satisfying the electric insulation required by the laws and ordinances related to consumer electric products while it maintains the sensing accuracy of the sensor.

**[0028]** The through port provided to the infrared ray condensing member of the refrigerator is higher than the leading end-face of the sensor by 3 mm or more. This structure allows limiting a view angle so that a target face for temperature sensing can be focused, because a target face for temperature sensing becomes greater at a greater view angle, so that the possibility of sensing other food than the target food in the target face increases, or the possibility of sensing temperatures of other faces than the target face also increases. The structure discussed above thus can minimize erroneous sensing done by the infrared sensor, and improve the stability of sensing accuracy can be further improved.

**[0029]** The refrigerator of the present invention comprises the following structural elements:

a heat-insulating box formed of multiple heat-insulating divisions;

heat-insulating partitions for partitioning the heat-insulating box;

storage compartments partitioned by the heat-insulating partitions;

an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment;

an infrared ray condensing member including a through port and provided to the infrared sensor; and

multiple protrusions provided around a protrusion opening that communicates with the through port of the infrared ray condensing member.

**[0030]** The foregoing structure allows preventing the infrared sensor from malfunctioning, breaking down, or damaging an element of the sensor by static electricity generated by rubbing the inner faces of the storage compartment with a cleaning towel.

**[0031]** The presence of the multiple protrusions around the protrusion opening allows preventing warm air from stagnating around the protrusions, where the warm air is introduced by disturbance, e.g. opening the door or putting hot food into the compartment, and this disturbance changes the ambient temperature of the infrared sensor.

As a result, the sensing accuracy of the infrared sensor can be improved.

**[0032]** The refrigerator of the present invention includes the infrared sensor mounting case that accommodates the infrared sensor, and the case has a protrusion on its surface. A slope having no rectangular section is provided on the outer wall of the protrusion. This structure prevents the protrusion from catching something for avoiding injury, so that safety of the sensor can be guaranteed. The slope guides convection to the leading end-face of the sensor, and the warm air thus can be prevented from stagnating around the sensor, and the temperature gradient relative to the sensor can be reduced. On top of that, the sensing accuracy of the sensor can be improved.

**[0033]** The refrigerator of the present invention includes the infrared ray condensing member of which leading end-face is approx. flush with the outer face, confronting the storage compartment, of the case. This structure allows eliminating steps between the infrared sensor mounting case and the infrared ray condensing member. This flush face structure allows preventing warm air introduced by opening the door or evaporated from food from stagnating. As a result, a smaller range of temperature change can be expected when the door is open, so that erroneous sensing by the infrared sensor due to sharp changes in ambient temperature can be prevented. The stability of sensing accuracy of the infrared sensor can be thus improved.

**[0034]** Exemplary embodiments of the present invention are demonstrated hereinafter with reference to the accompanying drawings. The present invention is not limited by these embodiments.

Exemplary Embodiment 1

**[0035]** Fig. 1 shows a lateral sectional view of an essential part of a refrigerator in accordance with the first embodiment of the present invention. Fig. 2A shows a lateral sectional view of a mounting section of an infrared sensor of the refrigerator shown in Fig. 1. Fig. 2B shows an enlarged view of an essential part of the mounting section shown in Fig. 2A.

**[0036]** As shown in Fig. 1 and Fig. 2A, freezer compartment 3 belongs to storage compartment of refrigerator 2 formed of heat-insulating box 1, and compartment 3 is separated from refrigerator compartment 6 and vegetable compartment 7 with upper heat-insulating partition 4 and lower heat-insulating partition 5 because freezer compartment 3 works in a temperature zone different from those of refrigerator compartment 6 or vegetable compartment 7. Partition 8 is provided to an opening (not shown) of freezer compartment 3 for connecting the left end to the right end of the opening.

**[0037]** In this first embodiment, partition 8 simply connects the left end to the right end of the opening; however, freezer compartment 3 can be separated into upper and lower divisions, and either one of the divisions can work in a different temperature zone. In such a case, partition 8 should be formed of heat-insulating material and cover the entire separating section such as upper heat-insulating partition 4 or lower heat-insulating partition 5.

**[0038]** Cool air generating compartment 9 placed behind freezer compartment 3 includes evaporator 10 for producing the cool air and blower 11 for supplying and circulating the cool air in refrigerator compartment 6, freezer compartment 3, and vegetable compartment 7. Defrosting heater 12 is placed under evaporator 10 and it is energized in the case of defrosting. Behind freezer compartment 3, there is cool air distributing compartment 19. Multiple cool-air blow-off ports 21, 22, and 33 communicate with cool air distributing compartment 19.

**[0039]** Freezer compartment 3 is closed at its openings with doors 23 and 24 to prevent the cool air from flowing out. Each one of doors 23 and 24 works as a part of a slide-out drawer, and when a user puts or takes out food in/from freezer compartment 3, the user pull the drawer this side of the refrigerator, i.e. to the left side in Fig. 1. Behind doors 23 and 24, there are frame 25 and 26 on which upper basket 27 and lower basket 28 are placed respectively.

**[0040]** The bottom face, i.e. a target face of infrared sensor 13, confronts sensor 13, and cool storage member 29 is placed on the target face. In general, cool storage member 29 keeps a temperature lower than that of the food to be frozen, and its melting temperature is set at -15°C that is higher than the temperature in freezer compartment 3. The amount of the material filled in cool storage member 29 is great enough not to melt completely when food is placed on cool storage member 29. Upper heat-insulating partition 4 includes infrared sensor 13 on its underside, i.e. facing to compartment 3, and is made of ABS resin. The other inner faces of compartment 3 are also made of ABS resin. Upper basket 27 and lower basket 28 are made of PP resin having heat characteristics similar to that of ABS resin. Lower behind freezer compartment 3, there is cool-air sucking port 30 for sucking and guiding the cool air to evaporator 10. Food 31 can be placed on cool storage member 29 for storage by the user.

**[0041]** Infrared sensor 13 is formed of infrared receptor 40, thermistor 42 and infrared element 43. Receptor 40 senses an amount of infrared ray radiated from an object existing in its visual field and then converts the infrared ray into electrical signals. Thermistor 42 measures an ambient temperature of receptor 40 as a reference temperature, and then it converts the temperature to electrical signals. Infrared element 43 includes receptor 40 and thermistor 42.

**[0042]** In this first embodiment, to sense a temperature of food 31 is an objective; however, infrared sensor 13 not only senses the temperature of food 31 but also senses temperatures of other things existing in the visual field of sensor 13, so that it senses amounts of infrared rays radiated from the inner wall of freezer compartment 3, food 31 stored in compartment 3, and cool storage member 29. During the sensing discussed above, the ambient temperature of infrared receptor 40 is measured as a reference temperature.

**[0043]** Infrared element 43 is electrically connected to wire 46, connector 44, and printed wired board 41. Connector 44 is electrically coupled to wiring 45 of a control board (not shown) which controls the refrigerator.

**[0044]** Infrared element 43 outputs a voltage of the reference temperature sensed by thermistor 42, and a voltage of the amount of infrared ray received by infrared receptor 40 to the control board (not shown), thereby calculating a temperature of an object sensed by the sensor, then the controller (not shown) determines, based on the calculated temperature, whether or not the object is food 31.

**[0045]** Infrared ray condensing member 48 covers infrared element 43 in a thermally contacting condition, and is mounted solidly to board 41, i.e. without any space between board 41. Condensing member 48 removes disturbance such as infrared rays radiated from the subjects other than food 31 and cool storage member 29, and guides the through-port 50 to infrared receptor 40 in order to restrict view angle θ° for increasing a sensing strength. Infrared ray condensing member 48 thus has the convergence function as discussed above, so that the height from leading end 50b to tailing end 50c of through port 50 is set not lower than 3 mm for limiting the view angle within 30 - 60°. In the case where the height of upper basket is approx. 110 mm, the view angle is preferably set at approx. 50°.

**[0046]** Through-port 50 obtains the strongest sensing strength at the center of the circle of a sensible range, and the strength becomes weaker at a greater distance from the center. Therefore, a narrower view angle of the infrared sensor will increase the intensity of the infrared ray radiated from the object, e.g. food 31, existing within the view angle. The temperature of the object can be thus more accurately sensed.

**[0047]** However, the view angle in parts overlap with inner wall 50a and leading end 50b of through port 50, so that the temperature to be sensed is somewhat affected by the temperatures of leading end 50b and inner wall 50a. This problem causes an erroneous sensing of the temperature. It is thus preferable that at least inner wall 50a, located within the view angle of the infrared sensor, of the through port 50 of infrared ray condensing member 48 should mitigate the properties of following the temperature variation due to disturbance, e.g. warm air flows into compartment 3 due to the opening of the door. The mitigation will result in a stable sensing. In this embodiment, infrared ray condensing member 48 is made of the material having greater heat conductivity and greater heat capacity so that inner wall 50a of through port 50 of condensing member 48 can have greater heat retainable force.

**[0048]** The technical term of "heat retainable force" in the present invention refers to responsiveness to the properties of following a temperature change in the event that thermal load such as temperature change is loaded to the ambient temperature. In other words, in the event of application of thermal load, the negative direction of following the temperature change indicates greater heat retainable force, and the positive direction thereof indicates smaller heat retainable force. The heat capacity can be described by an amount of heat radiation per unit surface area of the member exposed to the air. To be more specific, infrared ray condensing member 48 having a greater cubic volume has greater heat retainable force although members 48 have the same areas exposed to the air. Infrared ray condensing member 48 made of the material having a greater heat capacity has greater heat retainable force although members 48 have the same cubic volumes.

**[0049]** Operation of the refrigerator discussed above is demonstrated hereinafter. First, the refrigerator is turned on for starting a refrigerating cycle (not shown), then a refrigerant flows into evaporator 10, thereby generating cool air, which is then sent to cool-air distributing compartment 19 by blower 11, and the cool air is blown off from cool-air blown-off ports 21 and 22 into freezer compartment 3.

**[0050]** The cool air discharged into freezer compartment 3 cools down compartment 3 to a given temperature, and cool storage member 29 is simultaneously cooled down. At this time, the temperature of freezer compartment 3 is adjusted to the one, e.g. -20°C, at which food can be frozen for a certain period. However, since cool storage member 29, of which melting point is adjusted at -15°C, is used, member 29 will be completely frozen after a given time elapses from when freezer compartment 3 is sufficiently cooled. The cool air, which has cooled the inside of freezer compartment 3, is then sucked by cool-air sucking port 30 and enters cool-air generating compartment 9, and then is cooled down again by evaporator 10.

**[0051]** Infrared sensor 13 senses a temperature in this way: Assume that the ambient temperature, i.e. a reference temperature, of sensor 13 is 25°C, sensor 13 outputs a voltage "V", thermistor 42 measures the ambient temperature "S", an amount of infrared ray measured within a target area by infrared receptor 40 has an average temperature "B". Then the equation of $V = \alpha(8^4 - S^4)$ is established, where "$\alpha$" is a coefficient.

**[0052]** When there is no difference between ambient temperature "S" and average temperature "B" of the amount of infrared ray, infrared sensor 13 outputs voltage "V" closer to 0 (zero). When the difference becomes greater, a greater amount of infrared ray can be sensed by infrared receptor 40, so that sensor 13 outputs a greater voltage.

**[0053]** Assume that warm food is input in compartment 3, and ambient temperature "S", i.e. the reference temperature, of sensor 13 is raised by the warm food, and then the difference between ambient temperature "S" and average temperature "B" becomes smaller. Sensor 13, therefore, cannot sense that the food of relatively high temperature has been input. The sensing accuracy of infrared sensor 13 is thus obliged to lower.

**[0054]** If thermistor 42 can maintain a temperature without being changed by disturbance as discussed above, sensor 13 can sense a temperature accurately when, e.g. warm food is put in compartment 3.

**[0055]** In the case where door 23 is closed, infrared sensor 13 senses a temperature including a surface temperature of cool storage member 29 placed on the bottom face of upper basket 27, where the bottom face confronts infrared sensor 13 and works as an object face for sensor 13. The object face for sensor 13 to sense is thus formed of cool storage member 29 having cool storing function, so that the object face has greater heat retainable force. For instance, in the event of disturbance such as flow-in of warm air, the object face for infrared sensor 13 can mitigate the properties of following a temperature change because the object face has the greater heat retainable force. Sensor 13 thus can be hardly affected by disturbance and maintain a temperature more steadily, thereby sensing a temperature more accurately. In this case, the object face where cool storage member 29 is placed poorly follows a change in ambient temperature than the other faces, where no cool storage member 29 is placed, of upper basket 27, so that the object face can mitigate the properties of following the temperature change caused by disturbance. In other words, the object face, where cool storage member 29 is placed, for infrared sensor 13 radiates a smaller amount of heat per unit area than the other faces, where no cool storage member 29 is placed, of upper basket 27, so that the object face has greater heat retainable force.

**[0056]** As discussed above in this first embodiment, both of inner wall 50a of through port 50 of infrared ray condensing member 48 and the object face, i.e. the bottom face of upper basket 27, for sensor 13 are made of the material having great heat retainable force. The entire visual field of sensor 13 is thus made of the material having greater heat retainable force, thereby mitigating the properties of following the temperature change of the members existing in the visual field of sensor 13 in the event of a temporary change in the temperature due to disturbance. The structure discussed above allows infrared sensor 13 to sense the temperature of the object, i.e. food 31, more accurately.

**[0057]** When a user puts food 31 in compartment 3, the user pulls door 23. At this time, infrared sensor 13 senses the temperature in lower basket 28. In this first embodiment, in the event of opening door 23, the inside of lower basket 28 confronts sensor 13 and becomes an object for sensor 13; however, the inside of basket 28 is in approx. the same temperature zone as the original object face, i.e. the bottom face of upper basket 27, so that sensor 13 senses a freezing temperature and will not sense the higher temperature. This mechanism allows avoiding unnecessary fast freezing operation.

**[0058]** The refrigerator compartment having the door of a slide-out drawer is equipped with the infrared sensor as discussed above. In this case, employment of a sensor for opening/closing the door will sense the opening of the door, thereby halting the sensing operation of infrared sensor 13. As a result, an erroneous sensing can be prevented. However, this first embodiment does not employ the sensor for opening/closing the door, so that the temperature of the object face for sensor 13 may change when the door is opened, which causes an erroneous sensing. To overcome this problem, the storage compartment adjacent to the object face is preferably kept in the same temperature zone as that of the storage compartment equipped with infrared sensor 13 or in the lower temperature zone. Assume that this adjacent compartment is kept in the higher temperature zone, then sensor 13 senses the higher temperature, and then the control of accelerating the cooling operation by applying load to the refrigerating cycle is implemented. As a result, useless energy is consumed.

**[0059]** In the case of the refrigerator equipped with no sensor for opening/closing the door, it is preferable for the storage compartment, adjacent to the object face of the compartment equipped with the infrared sensor, to be kept in the same temperature range as or in the lower temperature range than the compartment equipped with the infrared sensor. This structure allows preventing an erroneous sensing in the event of opening the door, and more accurate sensing can be expected. As a result, the refrigerator can implement the cooling operation steadily in an energy saving manner.

**[0060]** In the event of opening door 23, warm air flows through the opening of door 23 from the outside, and flows along upper heat-insulating partition 4 placed on the ceiling of freezer compartment 3. Since leading end 50b of through port 50 of infrared ray condensing member 48 is flush with leading end-face 49a of recess 49, a smaller change in temperature can be expected when door 23 is opened. This structure thus prevents an erroneous sensing caused by sharp change in the ambient temperature, and improves the stability of sensing accuracy of infrared sensor 13.

**[0061]** Although the temperature at leading end 50b of through port 50 of infrared ray condensing member 48 rises due to the flow of warm air, the wall between leading end 50b and tailing end 50c resists having temperature gradient because condensing member 48 has great heat retainable force. Condensing member 48 thus can maintain a flat temperature overall, and infrared sensor 13 has no difference from the ambient temperature, so that more accurate sensing can be expected.

**[0062]** Fig. 3 shows a comparison of temperatures of the infrared ray condensing members 48 between open-door state and close-door state. The heat retainable force, i.e. the properties of following the temperature change, differs depending on the materials of condensing members 48, so that the heat retainable force of different materials are compared with each other in Fig. 3.

**[0063]** Three types of infrared ray condensing members 48 are compared: the first one is made of ABS resin which is generally used as the material for the inner face of conventional refrigerators, the second one is chiefly made of aluminum having higher heat conductivity as well as greater heat capacity for greater heat retainable force than the ABS resin, and the third one is made of highly electric conductive resin formed of powder oxide of high heat conductivity and high heat capacity. Although the powder oxide is rather expensive, it has electrical insulation. Powder metallic resin without housing, i.e. exposed to the air is compared with another powder metallic resin covered with housing of which heat conductivity is lower than that of the condensing member.

**[0064]** To be more specific, the powder metallic resin is chiefly made of alumina (aluminum oxide), and the alumina is dispersed in resin such as PPS, ABS, LSP (liquid crystal polymer) and then mixed and formed into highly heat conductive resin. Instead of alumina, either one of cilica or magnesia can be used.

**[0065]** The experimental condition is this: a refrigerator is placed at ambient temperature 38°C, a door of a freezer compartment kept at -17.5°C of the refrigerator is opened for 20 seconds (10 sec. - 30 sec. on X-axis in Fig. 3). The infrared sensor mounted in the freezer compartment senses temperatures, which vary with time as shown in Fig. 3.

**[0066]** As shown in Fig. 3, ABS resin widely used in conventional refrigerators raises the temperature of the storage compartment kept at -17.5°C to -3°C after the door is opened for 20 seconds, then the temperature gradually lowers; however it only lowers not lower than -15°C even 70 seconds elapse after the door is closed, so that the temperature does not lower to the original low temperature. Although it is not compared in this embodiment, PPS resin also widely used in the conventional refrigerators as ABS resin shows similar temperature characteristics to that of ABS resin.

**[0067]** On the other hand, the temperature of the condensing member made of aluminum rises temporarily to -7°C, and then lowers fast to the original low temperature, i.e.-17.5°C in 20 seconds after the door is closed. Since aluminum has great heat retainable force, the temperature of the inner wall, on which the warm air flows temporarily, of the condensing member rises; however, the condensing member per se made of aluminum retains the temperature of -17.5°C, i.e. the temperature kept before the door is opened, so that this temperature travels fast on the inner wall of the condensing member after the door is closed for lowering the temperature of the inner wall. In other words, the cool heat (i.e. the temperature of -17.5°C retained in the condensing member) stored in the condensing member until the door is opened can lower the temperature of the inner wall to the temperature of the condensing member, so that the infrared sensor can sense a temperature lowered fast.

**[0068]** Next, in the case of using the powder metallic resin, the temperature temporarily rises to approx. -7°C, and then it lowers fast to the original low temperature, i.e. -17.5°C in 20 seconds after the door is closed. This is the same phenomenon as the aluminum, because the powder metallic resin has greater heat retainable force, so that the temperature of the inner wall rises temporarily on which the warm air flows; however, since the condensing member itself retains the original temperature of -17.5°C, this temperature travels fast on the surface of the condensing member after the door is closed. In other words, the cool heat stored in the condensing member per se can lower the temperature of the inner wall to the temperature of the condensing member. As a result, the infrared sensor can sense a temperature lowered fast.

**[0069]** In the case of using a housing made of ABS resin as a heat retention promoting member, where the housing surrounds the powder metallic resin, the temperature does not rise so much in the event of opening the door, i.e. the temperature rises by 2.5°C to -15°C after 20 seconds since the door is opened. Then the temperature lowers fast to the original temperature, -17.5°C after 20 seconds elapse since the door is closed. In other words, infrared sensor 13 senses a temperature lowered fast.

**[0070]** The presence of the heat retention promoting member on the outer circumference of infrared ray condensing member 48 decreases the surface area from which heat is radiated when the warm air flows in, so that heat radiation is suppressed. Although the warm air flows on the inner wall of the condensing member, the temperature of the inner wall does not rise so fast because of the heat retainable force of the entire condensing member. Since the condensing member itself retains the original temperature of -17.5°C, this temperature travels fast on the surface of the condensing member after the door is closed. In other words, the cool heat (i.e. the temperature of -17.5°C retained in the condensing member), stored in the condensing member per se can lower the temperature of the inner wall to the temperature of the condensing member.

**[0071]** Infrared ray condensing member 48 is thus made of, e.g. aluminum, titanium, stainless steel, iron, or copper or the material including those metals which have greater heat conductivity and greater heat retainable force than ABS resin having widely used as the material for the condensing member or inner wall of the storage compartment of conventional refrigerators. Since infrared ray condensing member 48 is placed with the surface in parts exposed in freezer compartment 3, and it also should be lightweight, have high heat conductivity as well as great heat capacity, it is preferable to use aluminum as a chief ingredient among others, and the aluminum has high corrosion resistance in addition to the foregoing properties.

**[0072]** In the case of using infrared ray condensing member 48 with the surface in parts exposed in freezer compartment 3, static electricity generated by rubbing cleaner cloth against the inner wall by a user or static electricity charged on a human body will cause malfunction or bamage the infrared sensing element per se. To avoid the foregoing problems, it is preferable to use powder metallic resin, in particular, powder oxide resin because it has electrical insulation, higher heat conductivity, and greater heat capacity. For instance, one of alumina, silica, or magnesia is used as a chief ingredient, and it is dispersed in resin such as PPS, ABS, or LSP (liquid crystal polymer), and then compounded together, so that greater heat retainable force can be expected. This compound material then has higher heat retainable force, higher heat conductivity, and electrical insulation. The compounding ratio is preferably this: powder oxide takes 80% or more in wt%. The electric insulation is $1.0 \times 10^{14}$ Ωm or more at the same specific resistance as that of general resin member. This specification can meet the electric insulation stipulated in the laws and ordinances related to consumer electric products.

**[0073]** In the case of sensing a temperature of a subject stored in the storage compartment with infrared sensor 13, a change in temperature due to opening/closing the door tends to form temperature gradient along the wall between leading end 50b and tailing end 50c of through port 50 of infrared ray condensing member 48. The wt% of powder oxide is preferably adjusted at approx. 85% or more, so that the higher heat conductivity of 2W/mK or more can be expected. The heat capacity per unit mass is preferably 750J/kg°C or more.

**[0074]** As discussed above, at least the inner wall of infrared ray condensing member 48 has poorer properties of following the temperature change than the underside of upper heat-insulating partition 4, i.e. the inner face, made of ABS resin, confronting the inside of compartment 3. In other words, the inner wall of condensing member 48 has greater heat retainable force.

**[0075]** In this embodiment, infrared sensor mounting case 47 is used as the heat retention promoting member for increasing the heat retainable force of infrared ray condensing member 48, which is surrounded by condensing opening 51 of case 47, so that the heat capacity of condensing member 48 is increased, and variation in temperature of condensing member 48 can be further decreased.

**[0076]** In this case, infrared sensor mounting case 47 works as heat insulator surrounding infrared ray condensing member 48, of which outer surface is thus prevented from exposing to the air outside. This structure thus allows reducing the surface area contacting with the air outside, and slowing down the temperature change of the condensing member 48 kept at a certain temperature. The properties of following the temperature change caused by disturbance can be thus mitigated, so that the heat retainable force can be increased. Infrared sensor mounting case 47 thus works as the heat retention promoting member for increasing the heat retainable force.

**[0077]** In this embodiment, infrared sensor mounting case 47 working as the heat retention promoting member covers at least the outer face of infrared ray condensing member 48; however, case 47 made of material having lower heat conductivity than condensing member 48 can be used in other structures than the foregoing one. For instance, embedding the member made of rubber or butyl around infrared ray condensing member 48 will make this member as the heat retention promoting member, which can work as a sealing member when other components, e.g. the sensor, are mounted, and the sealing member is used for filling gaps between the components. Here is another structure: the ABS resin, which is widely used as inner wall of storage compartments of conventional refrigerators, can be used instead of rubber or butyl. Here is still another structure: Infrared ray condensing member 48 is surrounded by heat-insulating member having the lower heat conductivity. This structure allows condensing member 48 to have the greater heat retainable force, so that the properties of following the temperature change can be further mitigated. As a result, stable sensing accuracy of the infrared sensor can be expected.

**[0078]** As discussed above, the use of heat retention promoting member allows the inner wall of the infrared ray condensing member to radiate a smaller amount of heat per unit area than a general inner wall, made of ABS resin, of storage compartments. The inner wall of the infrared ray condensing member exists within a sensing field of the infrared sensor. As a result, stable sensing accuracy of the infrared sensor can be expected.

**[0079]** On top of that, the object face for the infrared sensor, i.e. a food placement face, which occupies a large portion of the sensing field of the infrared sensor, can be made of the material having greater heat retainable force than ABS resin. This structure allows the food placement face to radiate a smaller amount of heat per unit area. As a result, stable sensing accuracy of the infrared sensor can be expected. All the faces within the sensing range of the infrared sensor are thus made of the material having greater heat retainable force than ABS resin used as the inner wall to which the sensor is mounted, so that an amount of heat radiated per unit area from all the faces can be reduced. As a result, the properties of following the temperature change can be mitigated or degraded, whereby variation in temperature of the object face for the infrared sensor can be restricted, and stable sensing accuracy of the sensor can be expected.

**[0080]** Infrared sensor mounting case 47 has condensing opening 51 at its approx. center. Condensing opening 51 is shaped in the same form of the outer wall of infrared ray condensing member 48, and forms a through hole for accommodating condensing member 48 therein, so that sensor 13 is mounted to case 47. The face of infrared receptor 40 is in parallel with leading end-face 48a of condensing member 48, and leading end-face 48a extending to freezer compartment 3 is flush with the outer face of case 47. This structure reduces steps so that air can flow with ease along upper heat-insulating partition 4, i.e. the ceiling of freezer compartment 3, when door 23 or 24 is opened or closed. As a result, even if the warm air stagnates, it is difficult to form a temperature gradient between leading end 50b and tailing end 50c of through port 50.

**[0081]** As shown in Fig. 2B, inner wall 50a of through port 50 of infrared ray condensing member 48 shapes like a cone with its top cut-off, namely, its sectional view shows a trapezoid, and the top face of the cone with the top cut-off is 2.5 mm across and bottom face confronting the object face is 3.9 mm across. The height of the trapezoid is 4 mm, and the surface area of the cone with the top cut-off is 40.73 $mm^2$.

**[0082]** Infrared ray condensing member 48 extends toward upper heat-insulating partition 4, namely, opposite side to the object face where food 31 is placed, relative to placement face 40a of receptor 40 or placement face 42a of thermistor 42, and forms tailing end-face 48b. Two spaces are thus formed inside infrared ray condensing member 48, i.e. receptor 40 and thermistor 42 are placed between the two spaces.

**[0083]** Receptor 40 and thermistor 42 are thus placed in the cylindrical hollow space at the circle center of infrared ray condensing member 48, so that increment in the heat retainable force of condensing member 48 directly relates to the reduction in temperature variation of receptor 40 and thermistor 42.

**[0084]** The cubic volume of infrared ray condensing member 48 is 745.935 $mm^3$ which is more than double of the cubic volume of the condensing section, so that this structure allows condensing member 48 to have the heat capacity great enough relative to the surface area of 40.73 $mm^2$.

**[0085]** The cubic volume of infrared ray condensing member 48 is divided by the placement face 40a of receptor 40, and the space behind (upper side of) receptor placement face 40a has a greater cubic volume than the space below face 40a. In other words, the cubic volume between placement face 40a and the tailing end-face 48b of infrared ray condensing member 48 is greater than the cubic volume between placement face 40a and the leading end-face 48a. This structure allows the tailing end-face 48b side, which is less affected by the outside air, to have the greater heat capacity, so that the temperature variation caused by the ambient air can be mitigated. As a result, the condensing member with more stability toward heat is obtainable.

**[0086]** As discussed above, in this first embodiment, at least the inner wall of infrared ray condensing member 48 is made of the material having greater heat retainable force per unit cubic volume than the inner wall of the storage compartment where the infrared sensor is mounted. This structure allows the inner wall of the infrared ray condensing member to mitigate the properties of following the temperature change, caused by disturbance such as flow-in of warm air, where the inner wall falls within the visual field of the sensor. The infrared sensor thus can improve its temperature stability in the visual field, and suppress degradation in sensing accuracy with the simple construction discussed above. The degradation is caused by disturbance such as opening and closing the door, or placing hot food in the storage compartment, and the disturbance varies the ambient temperature of the sensing section of the sensor. The sensing accuracy of the infrared sensor can be thus improved.

**[0087]** Use of the metal of which chief ingredient is aluminum or powder metallic oxide as the condensing member allows the inner wall of the condensing member to restore fast to the original state from a temporarily varied state, i.e. the temperature of the inner wall namely the temperature of the surface exposed to the air is temporarily varied by disturbance. In the event of disturbance such as flow-in of warm air, the object face for the sensor has greater heat retainable force, thereby mitigating the properties of following the temperature change. The infrared sensor thus resists being affected by the temperature change, and can maintain a stable temperature. As a result, the more accurate sensing by the infrared sensor can be expected.

**[0088]** In the event that a temperature of the leading end of the infrared ray condensing member 48 differs from a temperature of thermistor 42, sensor 13 senses the temperature of the leading end, i.e. a temperature of a subject other than the object, whereby the sensing accuracy of sensor 13 is obliged to lower; however, this first embodiment can achieve reducing the temperature difference among thermistor 42, the inner wall of condensing member 48 and leading end 48a of member 48, so that the sensing accuracy of sensor 13 can be improved.

**[0089]** At least the inner wall of infrared ray condensing member 48 is poorer in the properties of following temperature-change than the underside, to which the infrared sensor is mounted, of the upper heat-insulating partition made of ABS resin, so that the inner wall has greater heat retainable force. The inner wall, therefore, resists being affected by variation in temperature caused by disturbance, so that the condensing member can maintain a stable temperature. As a result, more accurate sensing by the infrared sensor can be expected.

**[0090]** Surrounding infrared sensor 13 with infrared ray condensing member 48 having greater heat conductivity allows condensing member 48 to absorb the disturbance around sensor 13, e.g. variation in temperature caused by opening or closing the door, or putting hot food in the storage compartment. The temperature of sensor 13 thus becomes equal to the temperature of condensing member 48. The variation in ambient temperature of sensor 13 can be reduced, and thermal influence caused by the disturbance can be also reduced, so that changes in temperature can be suppressed. As a result, more accurate sensing by sensor 13 can be expected.

**[0091]** The present invention has infrared sensor 13 sense an amount of infrared ray radiated from the food and the like, which are the load to be sensed by sensor 13, placed in upper basket 27, and when the temperature calculated from the infrared ray amount exceeds a given value (upper limit temperature: T0), the refrigerator automatically starts quick chill control. After the quick chill control is set, if sensor 13 senses a temperature not higher than a given temperature (lower limit temperature: T1), the quick chill control is terminated.

**[0092]** The quick chill control operates this way: When a user puts some food in the storage compartment, sensor 13 senses a temperature not lower than T0, then the refrigerator automatically starts the quick chill control, then the refrigerator increases the rpm of the compressor (not shown), thereby increasing an amount of refrigerant circulating in the refrigerator for lowering the temperature of evaporator 10. On top of that, the rpm of blower 11 is increased for increasing an amount of cool air generated by evaporator 10 and circulating in the refrigerator, so that food 31 can be cooled fast. Then the temperature of food 31 is kept sensing by sensor 13 which then confirms that the temperature passes through the max. ice crystallization temperature zone, i.e. 0°C - (-)5°C, and the quick chill control is automatically terminated when the temperature reaches lower limit temperature T1 before the refrigerator enters into the regular operation. The refrigerator thus can pass quickly through the max. ice crystallization temperature zone that affects the food in view of food storage, and then returns to the regular cooling operation which little loses freshness of the stored food.

**[0093]** In this embodiment, the upper limit temperature, i.e. at which the quick chill control starts, T0 is set at -2.5°C, and the lower limit temperature, i.e. at which the quick chill control ends, T1 is set at -15°C to adapt the refrigerator to various situations of the food or the condition of storing the food.

**[0094]** As discussed above, this embodiment allows the refrigerator to enter into the quick chill control automatically, so that the cooling power is automatically increased. The refrigerator can be operated appropriately in response to the need. Conventional slow cooling operation to a temperature rise caused by inputting load in the storage compartment or to another load requiring fast cooling has been done by driving the compressor at a medium rpm; however, cooling the load with greater force for a shorter time can save electric power consumed by the refrigerator because of the shorter operating time. This embodiment thus proves that the refrigerator achieving greater energy saving is obtainable.

**[0095]** In the event of the automatic quick chill control discussed above, if the sensing accuracy of infrared sensor 13 is poor, the quick chill control starts uselessly; however, since the sensing accuracy is improved in this embodiment, the automatic quick chill control can be done with accuracy.

**[0096]** In this first embodiment as discussed above, the refrigerator comprises the following structural elements:

a heat-insulating box formed of multiple heat-insulating divisions;
heat-insulating partitions for partitioning the heat-insulating box;
storage compartments partitioned by the heat-insulating partitions;
an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment; and
an infrared ray condensing member surrounding the temperature sensing section and including a through port which guides a radiated amount of infrared ray to the infrared sensor.

**[0097]** The infrared ray condensing member has characteristics of heat conductivity greater than that of resin. The infrared ray condensing member surrounds the outside of the sensor and absorbs variation in temperature caused by the disturbance (e.g. opening/closing the door, or putting hot food in the storage compartment), so that the temperature of the infrared sensor becomes equal to that of the condensing member, and variation in ambient temperature of the sensor can be reduced and suppressed. As a result, more accurate sensing by the infrared sensor can be expected.

**[0098]** The refrigerator includes a recess formed on the heat insulating partition, the infrared sensor mounting case for accommodating the infrared sensor, and a condensing opening formed on the mounting case and shaped in the same form as the outer wall of the infrared ray condensing member, and this condensing opening forms a through hole. The infrared sensor mounting case is buried in the recess, so that the infrared ray condensing member is surrounded at its outer wall with resin member having a greater heat capacity. This structure allows the condensing member to have the greater heat capacity, and variation in temperature of the condensing member is suppressed. As a result, the sensing accuracy of the infrared sensor can be further improved.

**[0099]** The leading end of the infrared ray condensing member is buried in the recess so that it is flush with the entrance face of the recess. This structure allows warm air flowing into the storage compartment due to the opening or closing the door to pass on only the leading end of the entire condensing member. This flat free from tongue and groove allows preventing the warm air from stagnating. The warm air flows into the storage compartment due to the opening or closing the door or evaporates from the food stored in the storage compartment. When the door is opened, this structure suppresses the variation in temperature, so that an erroneous sensing caused by a sharp change in the ambient temperature of the sensor can be prevented, and the stability of sensing accuracy can be improved.

**[0100]** The infrared ray condensing member is made of metal of which chief ingredient is aluminum excellent in heat conductivity. Use of the aluminum will make heat responsiveness faster, and eliminate temperature gradient along through-port 50 of the condensing member, so that more accurate sensing by the infrared sensor can be expected.

**[0101]** The infrared ray condensing member is made of the electrically-insulating material compounded of resin and powder oxide, and the compounding ratio of powder oxide is 85% or more. This structure allows the condensing member to meet the electric insulation stipulated in the laws and ordinances related to the consumer electric products while the condensing member never degrades the sensing accuracy of the sensor.

**[0102]** Through-port 50 has a height of 3 mm or more from the leading end of the infrared sensor. A greater view angle of the sensor will cover a greater sensing object area to be sensed by the sensor, so that the sensor may sense a temperature of a face other than the face where food is placed, or other food than target food may exist on the object face. Since the height of through-port 50 is set at 3 mm or more, the view angle of the sensor can be limited, so that the object face to be sensed can be restricted. This structure allows minimizing erroneous sensing by the infrared sensor, and the stability of sensing accuracy can be further improved.

**[0103]** Infrared sensor 13, in general, senses an amount of infrared ray radiated from an object; however, hot food evaporates steam, which forms dew around recess 49 or sensor 13, and sensor 13 senses the heat energy of the dew (water) as a radiated amount of infrared ray. Sensor 13 thus senses a temperature of the dew attached around sensor 13 rather than senses a surface temperature of the food. As a result, sensor 13 cannot sense the surface temperature of the food accurately. In this embodiment, however, there is no intervening object such as a cover or a condensing lens between the infrared sensor and the food, so that the surface of the sensor directly communicates with the storage compartment. This structure allows preventing the sensor from lowering the sensing accuracy caused by the dew formation on the intervening objects.

Exemplary Embodiment 2

**[0104]** The second embodiment is demonstrated hereinafter with reference to Fig. 4. In this second embodiment, structural elements and technical idea similar to those used in the first embodiment are not detailed here.

**[0105]** Fig. 4 shows a lateral sectional view of an essential part of the refrigerator in accordance with the second embodiment. Infrared sensor 13 is mounted to freezer compartment 3, one of the storage compartments in the refrigerator. Sensor 13 comprises the following structural elements:

- infrared receptor 40 for sensing an amount of infrared ray radiated from objects existing in the visual field of sensor 13, and converting the amount to electrical signals;
- thermistor 42 for measuring an ambient temperature of receptor 40 as a reference temperature, and converting the temperature to electrical signals; and
- infrared element 43 for accommodating receptor 40 and thermistor 42.

In the event of placing food of high temperature outside the visual field of sensor 13, sensor 13 cannot sense the food.

**[0106]** In this second embodiment, multiple sensors are prepared in order to increase the sensing accuracy, namely, first infrared sensor 13a is provided at front side and second infrared sensor 13b is provided at rear side. On top of that, multiple cool-air blow-off ports are prepared, namely, first cool-air blow-off port 21a is provided for blowing off the cool air forward, and second blow-off port 21b is provided for blowing off the cool air backward.

**[0107]** This structure allows first sensor 13a to sense the temperature of the front side in upper basket 27 of freezer compartment 3, and second sensor 13b to sense the temperature of the rear side in upper basket 27. These two temperatures sensed by sensors 13a and 13b are compared with each other by a controller, so that at which region the load that needs cooling operation is input can be determined.

**[0108]** In the event of inputting warm food at some region in upper basket 27, cooling operation is focused to the region where one of sensors 13 senses the highest temperature among others, so that efficient cooling operation can be implemented, and the air volume from the multiple blow-off ports can be changed accordingly.

**[0109]** To be more specific, assume that first sensor 13a senses the higher temperature than the other, and then the refrigerator determines that warm food has been input at the front region. Second cool-air blow-off port 21b is then closed by a damper, and the cool air is blown off locally from first port 21a. This mechanism allows the food input at the front region in upper basket 27 to be cooled fast.

**[0110]** This quick chill prevents a temperature in the entire storage compartment from rising due to the warm food, so that other food stored in advance in the storage room can be prevented from loosing its freshness caused by a rise in temperature. The food of higher temperature is locally chilled instead of chilling all the food in the storage compartment, so that the cooling operation in an energy-saving manner can be achieved. Use of an automatic quick chill control based on the temperature sensed by the infrared sensor will quickly provide a necessary object with necessary amount of cooling, so that the refrigerator can save more energy.

**[0111]** In the case of the foregoing quick chill operation, the object face confronting infrared sensor 13, i.e. bottom face of upper basket 27, is preferably made of material having greater heat retainable force. This structure allows implementing faster quick chill operation even when heat load heavily increases by inputting warm food in the storage compartment.

**[0112]** Similar to the first embodiment, greater heat retainable force of the infrared ray condensing member that narrows the sensing range of the sensor will result in more accurate sensing while efficient and quick chill operation is implemented.

Exemplary Embodiment 3

**[0113]** The third embodiment is demonstrated hereinafter with reference to Figs. 5A and 5B. In this third embodiment, structural elements and technical idea similar to those used in the first and the second embodiments are not detailed here.

**[0114]** Fig. 5A shows a lateral sectional view of an essential part of the refrigerator in accordance with the third embodiment, and Fig. 5B shows a plan view of the freezer compartment of the refrigerator shown in Fig. 5A.

**[0115]** Infrared sensor 13 is mounted to freezer compartment 3, one of the storage compartments in the refrigerator. Sensor 13 comprises the following structural elements:

infrared receptor 40 for sensing an amount of infrared ray radiated from objects existing in the visual field of sensor 13, and converting the amount to electrical signals;
thermistor 42 for measuring an ambient temperature of receptor 40 as a reference temperature, and converting the temperature to electrical signals; and
infrared element 43 for accommodating receptor 40 and thermistor 42.

In the event of placing food of high temperature outside the visual field of sensor 13, sensor 13 cannot sense the food.

**[0116]** To overcome this problem, the third embodiment employs swivel infrared sensor 13c, which can change the sensing range with a movable mechanism. The entire infrared sensor 13c is movable such that at least infrared receptor 40 can move relative to width 27w of upper basket 27, and width 27w has centerline 27a along the longitudinal direction of the bottom face, on which object food is placed, of basket 27, and the bottom face works as the object face for sensor 13.

**[0117]** The width 27x of the visual field of sensor 13c with respect to width 27w of basket 27 can be expressed as follow:

$$27\mathbf{w}/2 \leq 27\mathbf{x} \leq 27\mathbf{w}$$

The visual field 27 of sensor 13 can be thus narrowed down, so that the sensing accuracy of temperature can be improved in the event of inputting some food, and the refrigerator can determine more accurately at which region the load requiring chill is input.

**[0118]** In the event of inputting warm food at some region in upper basket 27, cooling operation is focused to the region where one of sensors 13 senses the highest temperature among others is placed, so that efficient cooling operation can be implemented, and the air volume from the multiple blow-off ports can be changed accordingly.

**[0119]** To be more specific, assume that the region where sensor 13c senses the higher temperature among others is located at the front, i.e. near to door 23, the refrigerator then determines that the warm food has been input at the front region. Second cool-air blow-off port 21b is then closed by a damper, and the cool air is blown off locally from first port 21a. This mechanism allows the food input at the front region in upper basket 27 to be cooled fast.

**[0120]** This quick chill operation prevents a temperature in the entire storage compartment from rising, so that food stored in advance in the storage room can be prevented from loosing its freshness caused by a rise in temperature. The food of higher temperature is locally chilled instead of chilling all the food in the storage compartment, so that the cooling operation in an energy-saving manner can be achieved. Use of an automatic quick chill control based on the temperature sensed by the infrared sensor will quickly provide a necessary object with necessary amount of cooling, so that the refrigerator can save more energy.

**[0121]** In this third embodiment, multiple blow-off ports are provided for applying cool air locally to the region where greater load is placed, thereby operating quick chill control. However, a single blow-off port equipped with a louver that can change an air direction allows adjusting the air direction focusing on the region where greater load is placed. In this case, multiple blow-off ports are not needed, so that a target region can be locally cooled with the simpler structure.

**[0122]** In this embodiment, infrared sensor 13c per se is movable for enlarging a sensing area; however, the objective of this structure is to move the sensing face of sensor 13. When some condensing member such as a cover is formed on the sensing surface, only the opening of the condensing member should move. In such a case, the electric wiring of the sensor per se is not necessarily movable; but the opening of the condensing member can be movable. This structure can alleviate the load on the electric wirings or movable sections in a low temperature environment. As a result, infrared sensor 13c equipped with more reliable movable sections can be obtained.

Exemplary Embodiment 4

**[0123]** The fourth embodiment is demonstrated hereinafter with reference to Fig. 6 - Fig. 9. Fig. 6 shows a lateral sectional view of an essential part of the refrigerator in accordance with the fourth embodiment. Fig. 7 shows a lateral sectional view of an infrared sensor mounting section of the refrigerator shown in Fig. 6. Fig. 8 shows an enlarged view of section A in Fig. 7. Fig. 9 shows a plan view of the infrared sensor mounting section of the refrigerator shown in Fig. 4, viewed from just the above, i.e. along arrow mark B. In this fourth embodiment, structural elements and technical idea similar to those used in the first to the third embodiments are not detailed here.

**[0124]** As shown in Fig. 6 - Fig. 9, freezer compartment 103, a part of storage compartments of refrigerator 102 formed of heat-insulating box 101, is separated from refrigerator compartment 106 and vegetable compartment

107 by upper heat-insulating partition 104 and lower heat-insulating partition 105. Compartments 106 and 107 belong to different temperature zones from that of compartment 103. Freezer compartment 103 includes partition 108 at its opening (not shown) for connecting the right end to the left end of the opening.

**[0125]** Cool air generating compartment 109 placed behind freezer compartment 103 includes evaporator 110 for producing the cool air and blower 111 for supplying and circulating the cool air to refrigerator compartment 106, freezer compartment 103, and vegetable compartment 107. Defrosting heater 112 is placed under evaporator 110 and it is energized in the case of defrosting. Behind freezer compartment 103, there is cool air distributing compartment 119. Multiple cool-air blow-off ports 121 and 122 communicate with cool air distributing compartment 119.

**[0126]** Freezer compartment 103 is closed at its openings with doors 123 and 124 to prevent the cool air from flowing out. Each one of doors 123 and 124 works as a part of a slide-out drawer, and when a user puts or takes out food in/from freezer compartment 103, the user pull the drawer this side of the refrigerator, i.e. to the left side in Fig. 6. Behind doors 123 and 124, there are frames 125 and 126 on which upper basket 127 and lower basket128 are placed respectively, and slide-out middle basket 132 is placed on lower basket 128.

**[0127]** The bottom face of upper basket 127, i.e. a target face for infrared sensor 113, confronts sensor 113, and cool storage member 129 is placed on the target face. In general, cool storage member 129 keeps a temperature lower than that of the food to be frozen, and its melting temperature is set at -15°C that is higher than the temperature in freezer compartment 103. The amount of the material filled in cool storage member 129 is great enough not to melt completely when food is placed on cool storage member 129.

**[0128]** Lower behind freezer compartment 103, there is cool-air sucking port 130 for sucking and guiding the cool air to evaporator 110. Food 131 can be placed on cool storage member 129 by the user for storage.

**[0129]** Infrared sensor 113 is formed of infrared receptor 140, thermistor 142 and infrared element 143. Receptor 140 senses an amount of infrared ray radiated from an object existing in its visual field and then converts the infrared ray into electrical signals. Thermistor 142 measures an ambient temperature of receptor 140 as a reference temperature, and then it converts the temperature to electrical signals. Infrared element 143 includes thermistor 142 and receptor 140.

**[0130]** In this first embodiment, to sense a temperature of food 131 is an objective; however, infrared sensor 113 not only senses the temperature of food 131 but also senses temperatures of other things existing in the visual field of sensor 113, so that it senses amounts of infrared rays radiated from the inner wall of freezer compartment 103, food 131 stored in compartment 3, and cool storage member 129. At this time, the ambient temperature of infrared receptor 140 is measured as a reference temperature.

**[0131]** Infrared element 143 is electrically connected to wire 146, connector 144, and printed wired board 141. Connector 144 is electrically coupled to wiring 145 of a control board (not shown) which controls the refrigerator.

**[0132]** Infrared element 143 outputs a voltage of the reference temperature sensed by thermistor 142, and a voltage of the amount of infrared ray received by infrared receptor 140 to the control board (not shown), thereby calculating a temperature of an object sensed by the sensor, then the controller (not shown) determines, based on the calculated temperature, whether or not the object is food 131.

**[0133]** Infrared ray condensing member 148 covers infrared element 143 in a thermally contacting condition, and is mounted solidly to board 141, i.e. without any space between board 141. Condensing member 148 removes disturbance such as infrared rays radiated from the subjects other than food 131 and cool storage member 129, and guides the through-port 150 to infrared receptor 140 in order to restrict view angle θ° for increasing a sensing strength. Infrared ray condensing member 148 thus has the condensing function as discussed above, so that the height from leading end 150b to tailing end 150c of the inner wall of through port 150 is set not lower than 3 mm for limiting the view angle within 30 - 60°. In the case where the height of upper basket is approx. 110 mm, the view angle is preferably set at approx. 50°.

**[0134]** Through-port 150 obtains the strongest sensing strength at the center of the circle of a sensible range, and the strength becomes weaker at a greater distance from the center. Therefore, a narrower view angle of the infrared sensor will increase the intensity of the infrared ray radiated from the object. The temperature of the object can be thus accurately sensed.

**[0135]** However, the view angle in parts overlap with the leading end face of through port 150, so that the temperature to be sensed is somewhat affected by the temperatures of the leading end face. This problem causes an erroneous sensing of the temperature. It is thus preferable that at least inner wall 150a, located within the view angle of the infrared sensor, of the through port 150 of infrared ray condensing member 148 should mitigate the properties of following the temperature variation due to disturbance, e.g. warm air flows into the storage compartment due to the opening of the door. The mitigation will result in a stable sensing. In this embodiment, infrared ray condensing member 148 is made of the material having greater heat conductivity and greater heat capacity so that inner wall 150a of through port 150 of condensing member 148 can have greater heat retainable force.

**[0136]** Infrared ray condensing member 148 is thus made of, e.g. aluminum, titanium, stainless steel, iron, or copper or the material including those metals which have greater heat conductivity and greater heat retainable force than ABS resin having widely used as the material for the condensing member of conventional refrigerators.

Since infrared ray condensing member 148 is placed with the surface in parts exposed in freezer compartment 103, and it also should be lightweight, have high heat conductivity as well as great heat capacity, it is preferable to use aluminum as a chief ingredient among others, and the aluminum has high corrosion resistance in addition to the foregoing properties.

**[0137]** In the case of using infrared ray condensing member 148 with the surface in parts exposed in freezer compartment 103, static electricity generated by rubbing with cleaning cloth against the inner wall by a user or static electricity charged on a human body will cause malfunction or damage the infrared sensing element per se. To avoid the foregoing problems, it is preferable to use powder oxide because it has electrical insulation, higher heat conductivity, and greater heat capacity. For instance, one of alumina, silica, or magnesia is used as a chief ingredient, and it is dispersed in resin such as PPS, ABS, or LSP (liquid crystal polymer), and then compounded together, so that greater heat retainable force can be expected. This compound material then has higher heat retainable force, higher heat conductivity, and electrical insulation. The compounding ratio is preferably this: powder oxide takes 80% or more in wt%. The electric insulation is $1.0\times10^{14}$ Ωm or more at the same specific resistance as that of general resin member. This specification can meet the electric insulation stipulated in the laws and ordinances related to the consumer electric products.

**[0138]** In the case of sensing a temperature of a subject stored in the storage compartment with infrared sensor 113, a change in temperature due to opening/closing the door tends to form temperature gradient along the wall between leading end 150b and tailing end 150c of the inner wall of through port 150 of infrared ray condensing member 148. The wt% of powder oxide is preferably adjusted at approx. 85% or more, so that the higher heat conductivity of 2W/mK or more can be expected. The heat capacity per unit mass is preferably 750J/kg°C or more.

**[0139]** In this embodiment, infrared ray condensing member 148 is surrounded by the condensing opening 151 of infrared sensor mounting case 147 for increasing the heat retainable force of infrared ray condensing member 48, so that the heat capacity of condensing member 148 is increased, and variation in temperature of condensing member 148 can be further decreased.

**[0140]** In this case, infrared sensor mounting case 147 works as heat insulator surrounding infrared ray condensing member 148, of which outer surface is thus prevented from exposing to the air outside. This structure thus allows reducing the surface area contacting with the air outside, and slowing down the temperature change of the condensing member 148 kept at a certain temperature. The properties of following the temperature change caused by disturbance can be thus further mitigated.

**[0141]** Infrared sensor mounting case 147 has condensing opening 151 at its approx. center. Condensing opening 151 is shaped in the same form of the lateral face of infrared ray condensing member 148, and forms a through hole. Multiple protrusions 152 are provided around condensing opening 151 and extend toward inside the compartment. Infrared sensor mounting case 147 is provided on upper heat-insulating partition 104 such that it fits into recess 149 formed at the center of partition 104.

**[0142]** Within a circular inner wall formed by protrusions 152, there is protrusion opening 152a communicates with through port 150 of condensing member 148. This opening 152a has a greater opening face than through port 150.

**[0143]** Assume that the inner wall of condensing opening 151 forms a cylindrical protrusion extending 152 inside the compartment, then a step is formed between infrared ray condensing member 148 and the cylindrical protrusion, i.e. the inner wall. This structure tends to incur a warm-air reservoir at the space inside cylindrical protrusion 152. The warm air flowing into the compartment through opening doors 123 and 124 tends to stagnate in this reservoir, and the steam evaporating from food 131 also tends to stagnate in this reservoir. This warm-air reservoir produces a temperature gradient between the leading end and the tailing end of infrared ray condensing member 148, thereby causing an erroneous sensing by sensor 113. However, the present invention provides multiple protrusions 152 at intervals of "h3" to overcome the foregoing problem. This structure resists forming the warm-air reservoir around protrusions 152 in the event of the disturbance, e.g. opening/closing the door or inputting warm food. In other words, multiple protrusions 152 are not continuously or solidly formed but they are formed independently of each other on infrared sensor mounting case 147.

**[0144]** In this embodiment, protrusions 152 are formed such that air can flow through them with ease, and the presences of intervals h3 between the adjacent protrusions 152 and another interval h3' between the semicircular ends opposite to each other of protrusions 152 reduce air resistance, so that air can flow through with more ease.

**[0145]** As shown in Fig. 9, four protrusions 152 are placed at intervals of 90° so that they can surround infrared element 143 of sensor 113, and this structure allows the air to flow through with ease. Two protrusions 152 out of four are placed such that these two are in parallel with the front and behind direction X of the refrigerator, and the other two are placed in parallel with the right and left direction Y, crossing direction X at right angles, of the refrigerator. This structure will reduce the resistance in the air duct of the space between diameter "d1" of protrusion opening 152a and diameter "d2" of infrared ray condensing member 148 comparing with the case where protrusions 152 are placed at 30° or 45° relative to direction X or Y when cool air flows through the space between the diameter "d1" and diameter "d2" along direction X of the refrigerator.

**[0146]** In other words, protrusions 152 are not continuously linked together on the circle of diameter "d1" of protrusion opening 152a, but they are formed intermittently with intervals, so that a smaller resistance in the air duct can be expected. Protrusions 152 are placed in point-contact manner with the circle of diameter "d1" of protrusion opening 152a. To be more specific, on the circle of diameter "d1", only the semicircular shaped ends of protrusions 152 are positioned. On top of that, protrusions 152 occupies approx. 25% of the circular space of the inner most diameter "d3" communicating with the semicircular end of protrusions 152.

**[0147]** Except recess 149, face 104a of upper heat-insulating partition 104 facing to the inside of freezer compartment 103, outer face 147a, facing to the inside of compartment 103, of infrared sensor mounting case 147 and leading end-face 148a of condensing member 148 are flush with each other so that little step exists between those faces. This structure allows the warm air introduced into the compartment by opening doors 123 and 124 to flow with ease along partition 104, so that it is difficult to form the warm-air reservoir, whereby no temperature gradient is produced at the space between the leading end and the tailing end of infrared ray condensing member 148.

**[0148]** Outer face 147a of infrared sensor mounting case 147 is thus flush with end face 148a of infrared ray condensing member 148, in other words, the spaces of interval "h3" where no protrusions 152 exist are flush with end face 148a of condensing member 148, so that smaller resistance against the air flow can be expected, which makes it difficult to form the warm-air reservoir.

**[0149]** In the structure discussed above, only protrusions 152 project from the ceiling, to which infrared sensor 113 is mounted, of the storage compartment, and the presence of protrusions 152 prevents a cleaning towel from touching directly to infrared sensor 113. As a result, infrared sensing element 143 of sensor 113 is protected from malfunction or breakdown per se due to electrostatic discharge (ESD) caused by static electricity produced by rubbing the cleaning towel against the wall or static electricity charged on a human body.

**[0150]** Protrusions152 used in this embodiment are made of different material from that of infrared ray condensing member 148, and protrusions152 are most accessible from a user because they are placed nearest to the storage compartment among other structural elements of infrared sensor 113. On top of that infrared ray condensing member 148 lies between protrusions 152 and sensor 113, so that protrusions 152 do not touch sensor 113 directly. This structure allows preventing the static electricity generated by a contact between the user and protrusions 152 or ESD of the static electricity charged on a human body from causing a malfunction of sensor 13 or a breakdown of infrared element 114.

**[0151]** As discussed above, to further mitigate the properties of infrared ray condensing member 148, the properties of following a temperature change caused by disturbance, the shape of protrusions 152 placed in the visual field of sensor 113 is designed to prevent the formation of warm-air reservoirs around protrusions 152. This structure allows improving the sensing accuracy of sensor 113.

**[0152]** Protrusions 152 are made of different material from that of infrared ray condensing member 148, and protrusion 152 are preferably made of the material having lower heat conductivity than that of member 148. This structure prevents the heat of protrusions 152 from traveling to infrared ray condensing member 148, so that the temperature of member 48 can be more stable, which improves the sensing accuracy of sensor 113.

**[0153]** The static electricity charged on a human body sometimes exceeds 1000V, so that a given space distance "h2" shown in Fig. 8 is set at 6 mm or longer for preventing a user's finger from touching sensor 113. This structure provides the user with greater safety, and the space distance "h2" is preferably set at 6 mm or longer in the range where the visual angle of sensor 113 does not overlap with protrusions 152. Protrusion opening 152a, i.e. inner diameter of the circle formed by protrusions 152 is set at 6 mm or greater for preventing a user's finger from entering the opening along the vertical direction. Intervals "h3" between adjacent protrusions 152 are set at 4 mm each or smaller for preventing the user's finger from entering along the lateral direction. As a result, the foregoing structure secures insulating distances enough for practical use of the refrigerator.

**[0154]** On top of that, slopes 153 are provided in a cross shaped manner and without right-angled sections from protrusion opening 152a to the surface of infrared sensor mounting case 147. This structure prevents the cleaning towel from catching on protrusions 152 or food 131 placed in the storage compartment from catching on or a user's finger from hitting against protrusions 152. Food 131 can be thus prevented from going bad, and user's finger can be prevented from being injured. The presence of slopes 153 allows the air to flow with ease along the ceiling, i.e. heat-insulating partition 104, to slopes 153, so that it is difficult to form the warm-air reservoir that causes to form a temperature gradient between the leading end and tailing end of infrared ray condensing member 148. As discussed above, the slopes provided on the outer face of protrusions 152 have no right-angled sections, and are formed of curves, so that nothing catches on them.

**[0155]** The operation of the foregoing refrigerator is demonstrated hereinafter. First, the refrigerator is turned on for starting a refrigerating cycle (not shown), then a refrigerant flows into evaporator 110, thereby generating cool air, which is then sent to cool-air distributing compartment 119 by blower 111, and the cool air is blown off from cool-air blown-off ports 121 and 122 into freezer compartment 103.

**[0156]** The cool air discharged into freezer compartment 103 cools down compartment 103 to a given temperature, and cool storage member 129 is simultaneously cooled down. At this time, the temperature of freezer compartment 103 is adjusted to the one, e.g. -20°C, at which food can be frozen for a certain period. However, since cool storage member 129, of which melting point is adjusted at -15°C, is used, it will be completely frozen after a given time elapses from when freezer compartment 103 is sufficiently cooled. The cool air, which has cooled the inside of freezer compartment 103, is then sucked from cool-air sucking port 130 and enters cool-air generating compartment 109, and then is cooled down again by evaporator 110.

**[0157]** Infrared sensor 113 senses a temperature this way: Assume that the ambient temperature, i.e. a reference temperature, of sensor 113 is 25°C, sensor 113 outputs a voltage "V", thermistor 142 measures the ambient temperature "S", an amount of infrared ray measured within a target area by infrared receptor 140 has an average temperature "B". Then the equation of $V = \alpha(B^4 - S^4)$ is established, where "$\alpha$" is a coefficient.

**[0158]** When there is a smaller difference between ambient temperature "S" and average temperature "B" of the amount of infrared ray, infrared sensor 113 outputs voltage "V" closer to 0 (zero). When the difference becomes greater, a greater amount of infrared ray can be sensed by infrared receptor 140, so that sensor 113 outputs a greater voltage.

**[0159]** Assume that warm food is input in compartment 103, and ambient temperature "S", i.e. the reference temperature, of sensor 113 is raised by the warm food, then the difference between ambient temperature "S" and average temperature "B" becomes smaller. Sensor 113, therefore, cannot sense that the food of relatively high temperature has been input although the absolute temperature of the food is high. The sensing accuracy of infrared sensor 13 is thus obliged to lower.

**[0160]** In the case where door 123 is closed, infrared sensor 113 senses a temperature including a surface temperature of cool storage member 129 placed on the bottom face of upper basket 127, where the bottom face confronts infrared sensor 113 and works as an object face for sensor 113. The object face for sensor 113 to sense is thus formed of cool storage member 129 having cool storing function. For instance, in the event of disturbance such as flow-in of warm air, the object face for infrared sensor 113 thus can mitigate the properties of following a temperature change because the object face has the greater heat retainable force. Sensor 113, therefore, can be hardly affected by disturbance and maintain a temperature more steadily, thereby sensing a temperature more accurately.

**[0161]** As discussed above in this embodiment, both of inner wall 150a of through port 150 of infrared ray condensing member 148 and the object face, i.e. the bottom face of upper basket 127, for sensor 113 are made of the material having great heat retainable force. This structure allows mitigating the properties of following the temperature change of the members existing in the visual field of sensor 113 in the event of a temporary change in the temperature due to disturbance. The structure discussed above allows infrared sensor 113 to sense the temperature of the object, i.e. food 131, more accurately.

**[0162]** Inside the circle formed by protrusions 152, protrusion opening 152a is provided to infrared ray condensing member 148 at the storage compartment side, and opening 152a communicates with through-port 150. Opening 152a has a greater opening area than through port 150, so that protrusions 152 existing in the visual field of sensor 113 can be smaller, which prevents the sensing accuracy of sensor 113 from degrading because sensor 113 may adversely sense protrusions 152. This structure also invites an idea about the shape which makes it difficult to form the warm-air reservoir, thereby preventing the malfunction of sensor 113 due to static electricity produced by a contact with a user while the sensing accuracy of sensor 113 can be maintained. As a result, the refrigerator equipped with the highly reliable infrared sensor can be obtained.

**[0163]** Four protrusions 152 are prepared in this embodiment, and two protrusions 152 out of the four are placed such that these two are in parallel with the front and behind direction X (the cool air flows along direction X) of the refrigerator, and the other two are placed in parallel with the right and left direction Y, crossing direction X at right angles, of the refrigerator. This structure will reduce the resistance in the air duct of the space between diameter "d1" of protrusion opening 152a and diameter "d2" of infrared ray condensing member 148 comparing with the case where protrusions 152 are placed at 30° or 45° relative to direction X or Y when cool air flows through the space between the diameter "d1" and diameter "d2" along direction X of the refrigerator.

**[0164]** The inventors of the present invention place the four protrusions at various angles for measuring the temperature of infrared ray condensing member 148, and find that the least change in temperature is measured with the foregoing structure.

**[0165]** Protrusions 152 make point-contact with the circle, having diameter "d1", of opening 152a that is the inside space of protrusions 152. To be more specific, only the semi-circular ends of protrusions 152 are positioned on the circle, having diameter "d1", of opening 152a. Protrusions 152 occupy approx. 25% of the inner most circle having diameter "d3", where the circle of diameter "d3" communicates with the semicircular ends of protrusions 152 in the sectional view. However, according to the experiment by the inventors, the occupying ratio of not greater than 1/3 instead of 1/4 (25%) makes it difficult to form the warm-air reservoir. It is therefore preferable to design protrusions 152 to occupy the inner most circle of diameter "d3" at least not greater than 1/3.

**[0166]** When a user inputs food 131 in freezer compartment 103, the user draws, e.g. door 123. At this time, infrared sensor 113 senses a temperature inside lower basket 128, and then door 123 opens and warm-air outside flows in through the opening of door 123, and travels along the ceiling, i.e. upper heat-insulating partition 104 and slope 153. Since the leading end of infrared ray condensing member 148 is flush with the outer face of infrared sensor mounting case 147, the air flows along slope 153 even when door 123 is opened. This structure allows reducing a change in temperature caused by the stagnation of warm air, so that an erroneous sensing due to a sharp change in temperature can be eliminated. As a result, the sensing accuracy of sensor 113 can be improved.

**[0167]** In the case of cleaning the inside of storage compartment, e.g. freezer compartment 103, static electricity is charged by rubbing a towel against the inner wall of the compartment. In a dry season, static electricity tends to be charged on a human body, and if the user charged with static electricity touches sensor 113, the finger end or the towel produces electrostatic discharge (ESD), and when the discharging energy is applied to sensor 113, noises erroneously enter infrared element 143, thereby causing malfunction of sensor 113, or element 143 per se cannot bear the withstanding electrostatic voltage so that a burn out or a short circuit inside element 143 occurs.

**[0168]** As discussed previously, multiple protrusions 152 extend toward inside the compartment and surround condensing opening 151. The presence of protrusions 152 allows maintaining a given space so that malfunction, breakdown, or damage of sensor 113 due to static electricity can be prevented, and also allows preventing a user's finger from entering opening 151 and touching an electrical component directly, e.g. infrared element 143.

**[0169]** As discussed above, in this fourth embodiment, the refrigerator of the present invention comprises the following structural elements:

a heat-insulating box formed of multiple heat-insulating divisions;
a heat-insulating partition for partitioning the heat-insulating box;
storage compartments partitioned by the heat-insulating partitions;
a recess formed on the heat-insulating partition;
an infrared sensor for sensing an amount of infrared ray radiated from an object stored in the storage compartment;
an infrared ray condensing member surrounding the infrared sensor and including a through port guiding the amount of infrared ray to the infrared sensor;
an infrared sensor mounting case for accommodating the infrared sensor;
a condensing opening shaped in the same form as the lateral face of the infrared ray condensing member and extending through the infrared sensor mounting case which is buried in the recess; and
multiple protrusions provided around the condensing opening and extending toward the storage compartment.

**[0170]** The foregoing structure allows preventing the infrared sensor from malfunctioning, breaking down, or damaging itself caused by static electricity generated by rubbing the inner face of the storage compartment with a cleaning towel.

**[0171]** The presence of the multiple protrusions around the condensing opening allows preventing warm air from stagnating around the protrusion caused by disturbance, e.g. opening the door or putting hot food into the compartment, and the disturbance changes the ambient temperature of the infrared sensor. As a result, the sensing accuracy of the infrared sensor can be improved.

**[0172]** The distance between the end face of infrared sensor and the protrusion of the infrared sensor mounting case is set at 6 mm or more, whereby the refrigerator can meet the insulating distance to an electric component, i.e. infrared sensor, where the insulating distances are stipulated in the laws and ordinances related to the consumer electric products. On top of that, when the static electricity charged in a human body, which sometimes exceeds 1000 volts, produces electrostatic discharge (ESD) and the discharging energy is applied to the sensor, a given distance thus maintained will prevent the infrared sensor from malfunctioning, breaking down, or prevent the infrared element per se from being damaged.

**[0173]** The inner diameter of the circle formed by the protrusions is set at 6 mm or less. This structure prevents a human finger from entering the inside of the protrusions along the vertical direction, so that the finger cannot directly touch an electric component, i.e. the infrared sensor.

**[0174]** The protrusions are placed around the opening at equal intervals, namely, 4 mm or smaller, so that the user's finger cannot enter along the lateral direction, and the finger cannot touch the sensor directly.

**[0175]** A slope running from the protrusions to the outside of the condensing opening is provided on the surface of the infrared sensor mounting case, so that nothing catches on the protrusions and no injury can happen. The presence of the slope thus assures the safety. On top of that, convection can travel along the slope to the leading end of the sensor, whereby a warm-air reservoir to be formed around the sensor can be avoided and a formation of temperature gradient around the infrared receptor can be prevented. As a result, the sensing accuracy of the infrared sensor can be further improved.

**[0176]** The leading end of the infrared ray condensing member is flush with the outer face, confronting the inside of the storage compartment, of the infrared sensor mounting case, so that steps between the case and the condensing member can be eliminated. This structure allows preventing warm-air from stagnating, so that warm air flowing into the compartment by opening the door or steam evaporating from food stored in the compartment cannot stagnate. When a user opens the door, little change in temperature can be expected, so that erroneous sensing caused by a sharp change in temperature can be avoided. As a result, more stable sensing accuracy of the sensor can be expected.

**[0177]** In this embodiment, face 104a except recess 149 of upper heat-insulating partition 104 facing to the inside of freezer compartment 103, outer face 147a, confronting the inside of freezer compartment 103, of infrared sensor mounting case 147 are flush with each other. However, outer face 147a confronting the inside of freezer compartment 103 can protrude from face 104a toward the inside of compartment 103. This structure, i.e. outer face 147a protrudes rather than face 104a, avoids the formation of warm-air reservoir around the protrusions of case 147 in the event of opening/closing the door, so that it makes difficult to form the temperature gradient between the leading end and the tailing end of infrared ray condensing member 148. In this case, a protruding shape can be provided only around mounting face 147b where protrusions 152 are formed. Face 104a can be flush with outer face 147a, facing to the inside of the compartment 103, of infrared sensor mounting case 147, and only mounting face 147b can protrude smoothly. In this case, the rigidity around protrusion-mounted face 147b can be increased, and the refrigerator equipped with a non-contact sensor having more reliable protrusions 152 is obtainable.

Industrial Applicability

**[0178]** An infrared sensor of a refrigerator of the present invention improves the sensing accuracy free from influence of ambient disturbance, e.g. temperature variation caused by opening/closing the door, or inputting warm food. The specification of the sensor meets the electrical insulation stipulated in the laws and ordinances related to the consumer electric products, so that the sensor can improve the quality of the refrigerator. The infrared sensor can be employed not only in the household refrigerator but also in the professional type refrigerator, measuring devices used in the circumstances greatly affected by the ambient disturbance.

**[0179]** In a refrigerator of the present invention, protrusions and slopes are formed on the parts of an infrared sensor mounting case, so that a given space can be provided between an infrared element and the mounting case. This structure allows preventing erroneous sensing or breakdown caused by static electricity, or preventing an internal destruction of the infrared element per se. On top of that, the sensor is not affected by disturbance occurring around the protrusions, e.g. temperature variation caused by opening/closing the door or warm food, and can improve the sensing accuracy. The refrigerator secures the electrical insulation stipulated in the laws and ordinances related to the consumer electric products, so that the sensor can improve the quality of the refrigerator. The refrigerator thus can be used not only as the household refrigerator but also as the professional type refrigerator.

**Claims**

**1.** A refrigerator comprising:

a heat-insulating box formed of multiple heat-insulating divisions;
a heat-insulating partition for partitioning the heat-insulating box;
a storage compartment partitioned by the heat insulating partition;
an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment; and
an infrared ray condensing member provided closer to an inner side of the storage room than to the infrared sensor,
wherein at least an inside wall face of the infrared ray condensing member has greater heat retainable force.

**2.** The refrigerator of claim 1 further comprising an infrared sensor mounting case which accommodates the infrared sensor, wherein an condensing opening, which is shaped in a similar form to a lateral face of the infrared ray condensing member and extends through the mounting case, which is buried in a recess formed at the heat insulating partition.

**3.** The refrigerator of claim 2, wherein the infrared ray condensing member is buried in the recess such that a leading end of the condensing member is flush with an entrance face of the recess.

**4.** The refrigerator of any one of claim 1 - claim 3, wherein the infrared ray condensing member is made of metal of which chief ingredient is aluminum.

**5.** The refrigerator of any one of claim 1 - claim 3, wherein the infrared ray condensing member is made of electrically insulating compound formed of resin and powder oxide of which compounding ratio is 85% or greater.

**6.** The refrigerator of any one of claim 1 - claim 5, wherein a through port is provided to the infrared ray condensing member, and the through port has a height of 3 mm or greater from a leading end of the infrared sensor.

**7.** A refrigerator comprising:

a heat-insulating box formed of multiple heat-insulating divisions;
a heat-insulating partition for partitioning the heat-insulating box;
a storage compartment partitioned by the heat insulating partition;

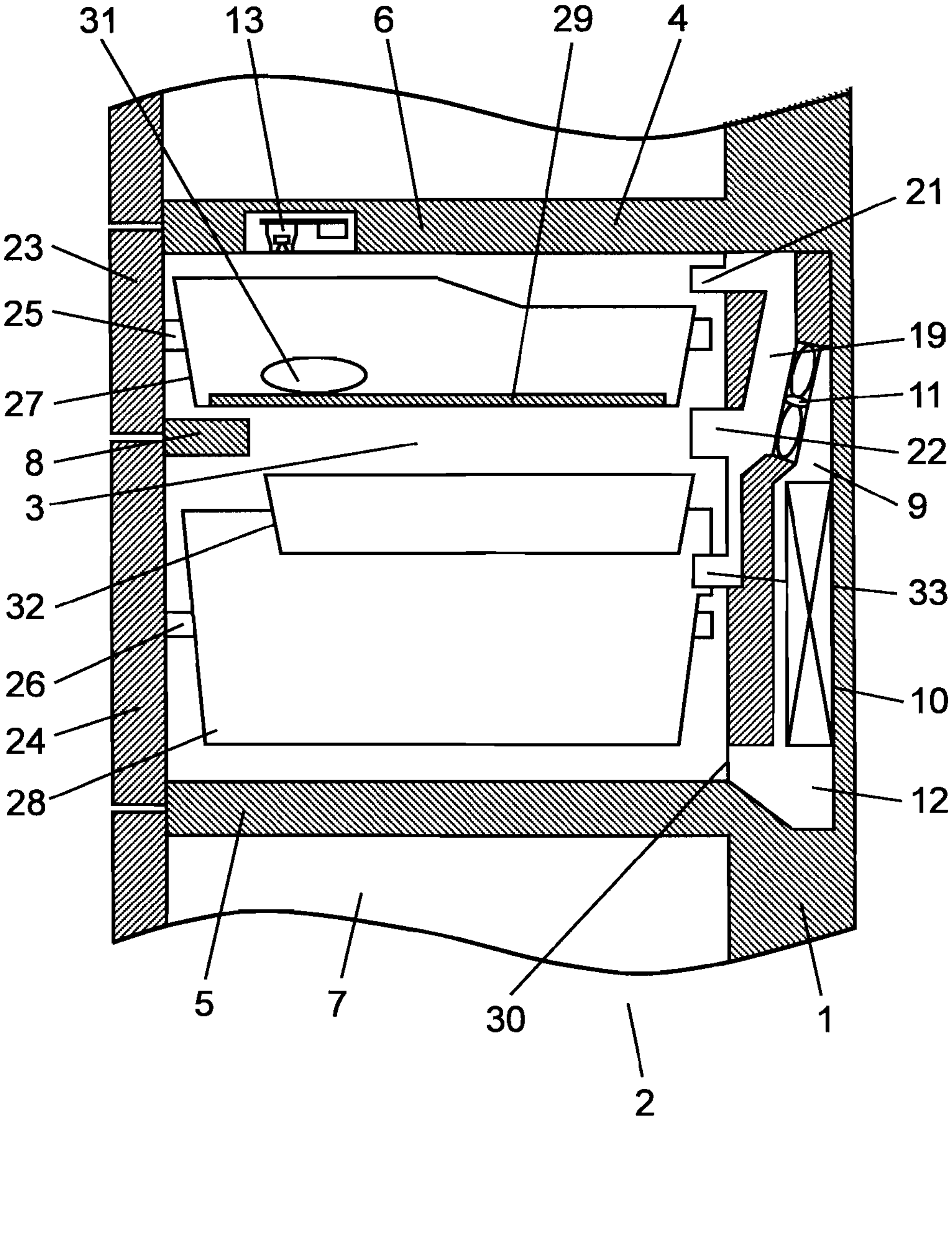
an infrared sensor including a temperature sensing section for sensing an amount of infrared ray radiated from an object stored in the storage compartment; and

an infrared ray condensing member provided to the infrared sensor and having a through port, wherein a protrusion opening communicating with the through port of the condensing member is provided and a plurality of protrusions is provided around the protrusion opening.

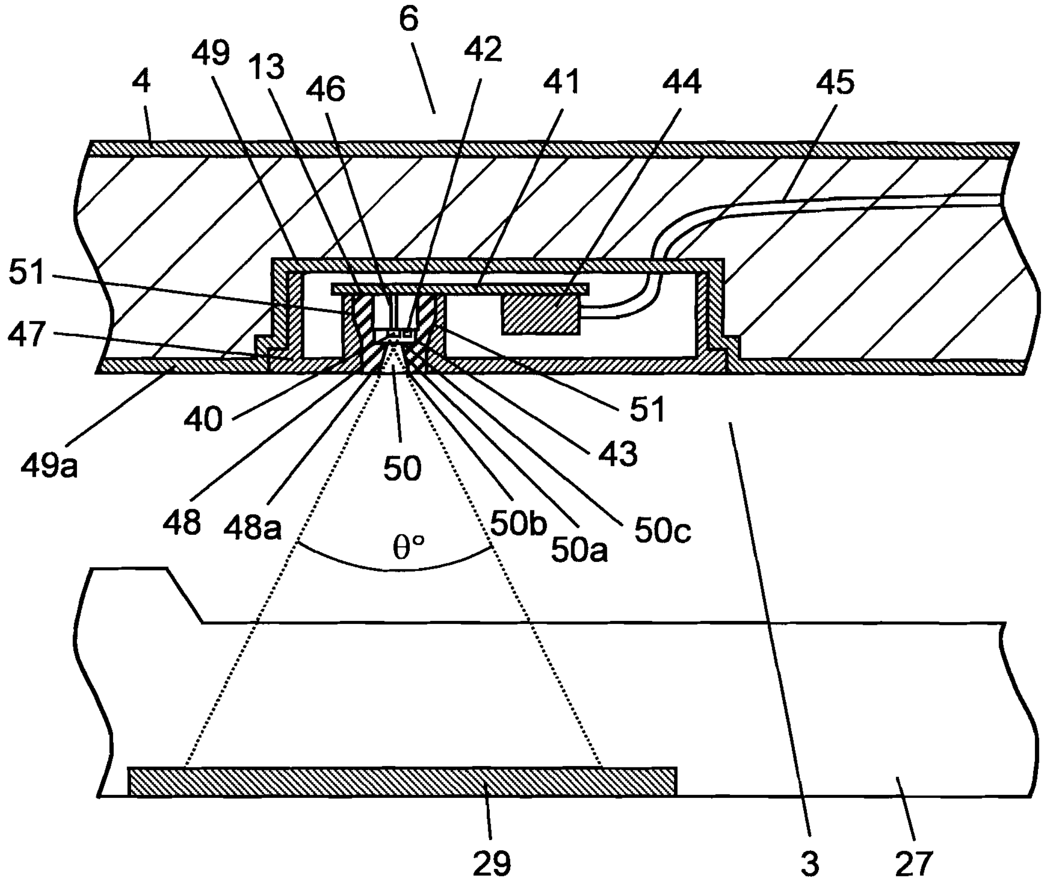
**8.** The refrigerator of claim 7 further comprising an infrared sensor mounting case for accommodating the infrared sensor, wherein the protrusions are formed on a surface of the infrared sensor mounting case, and a slope having no right-angled sections is formed outside the protrusions.

**9.** The refrigerator of claim 8, wherein a leading end of the infrared ray condensing member is substantially flush with an outer face, facing inside the storage compartment, of the infrared sensor mounting case.

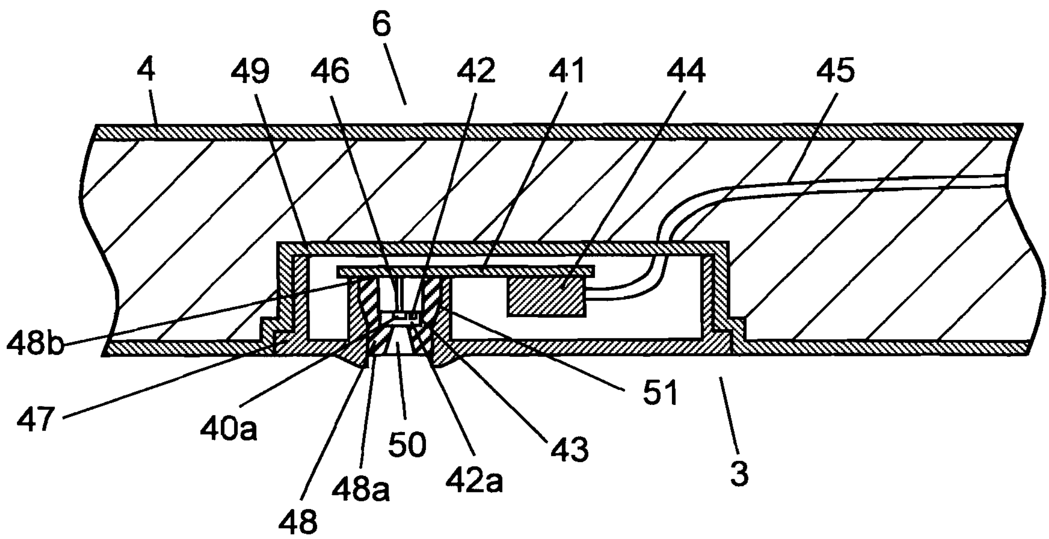
FIG. 1



# FIG. 2A


6
4
49
13
46
42
41
44
45
51
47
51
40
49a
43
50
48
48a
50b
50c
50a
θ°
29
3
27

# FIG. 2B


6
4
49
46
42
41
44
45
48b
51
47
40a
50
43
3
48a
42a
48

# FIG. 3

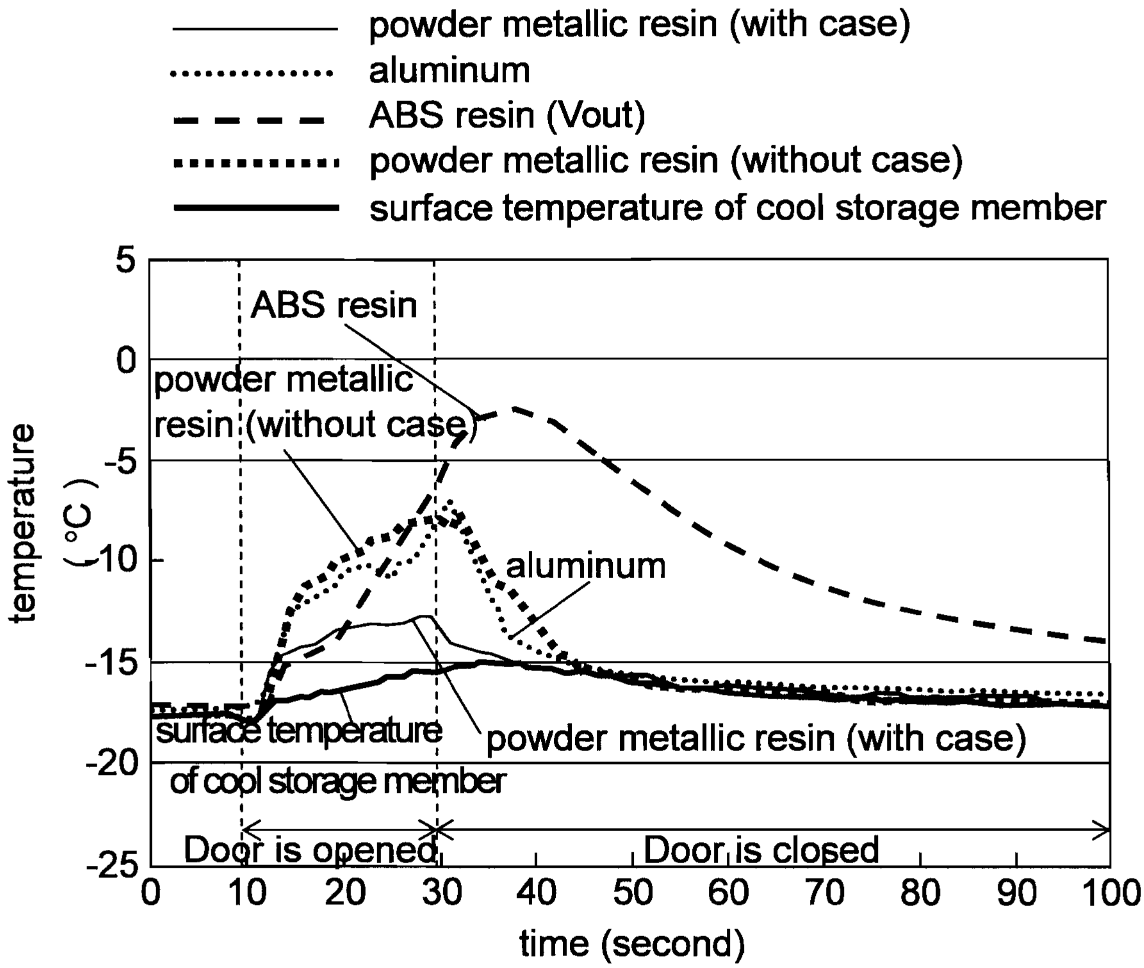

powder metallic resin (with case)
aluminum
ABS resin (Vout)
powder metallic resin (without case)
surface temperature of cool storage member
ABS resin
powder metallic resin (without case)
aluminum
surface temperature of cool storage member
powder metallic resin (with case)
Door is opened
Door is closed
temperature (°C)
time (second)
5
0
-5
-10
-15
-20
-25
0
10
20
30
40
50
60
70
80
90
100

FIG. 4

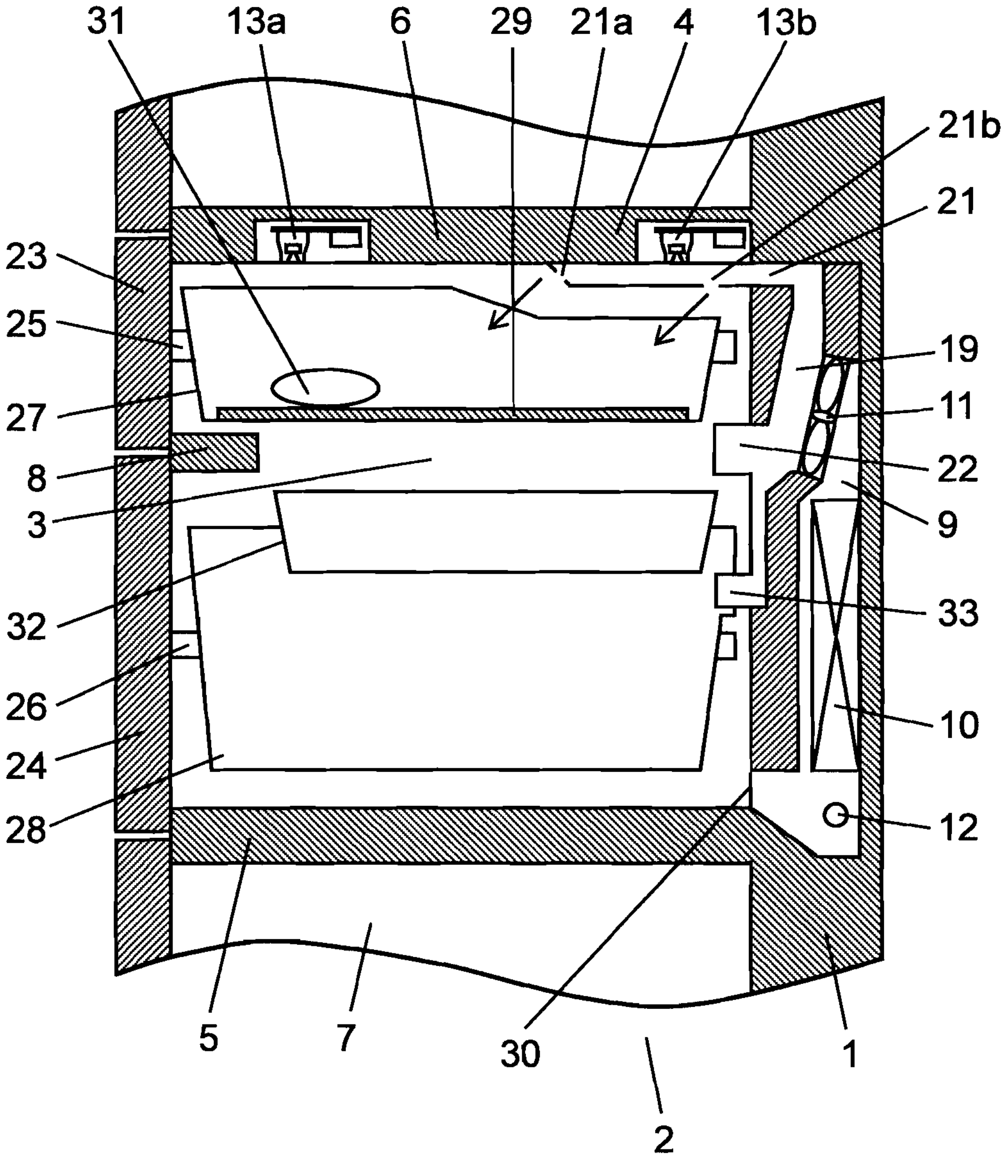

31
13a
6
29
21a
4
13b
21b
21
23
25
19
11
27
22
8
3
9
32
33
26
10
24
28
12
5
7
30
1
2

FIG. 5A

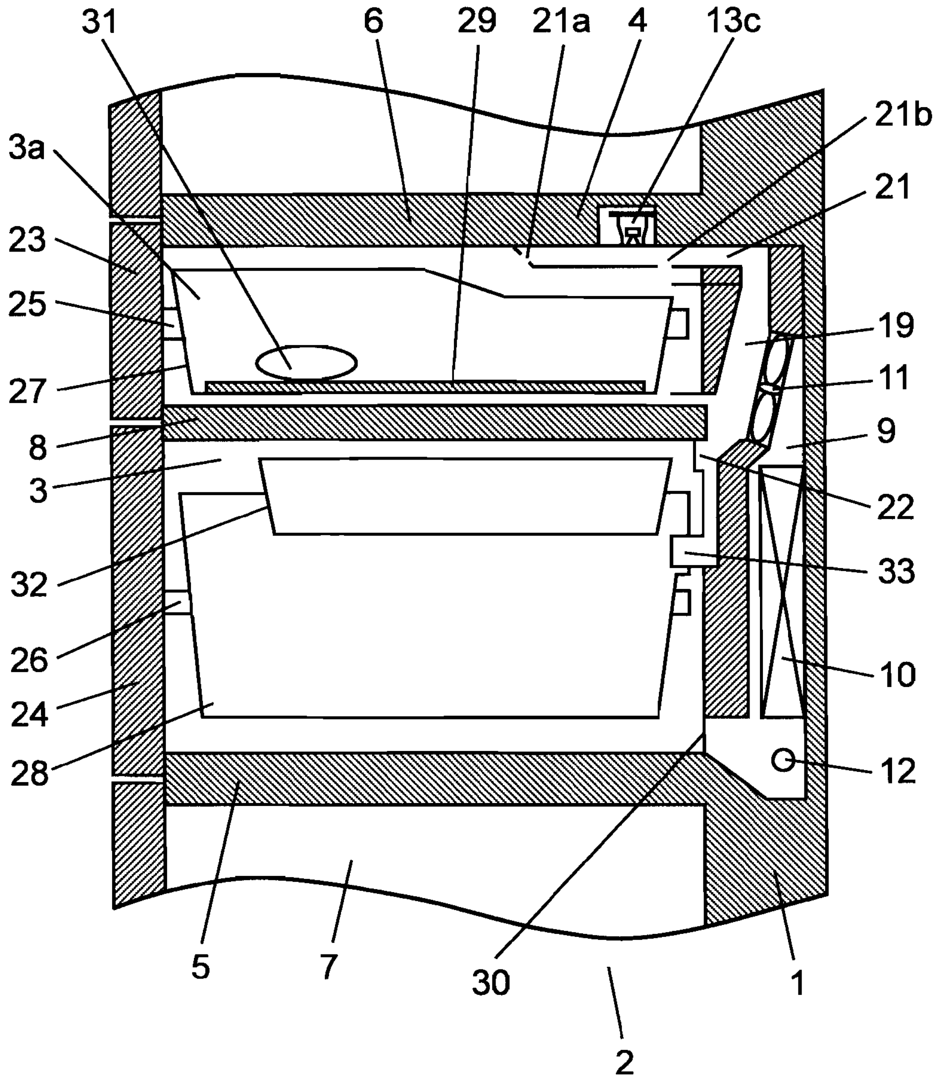

31
6
29
21a
4
13c
21b
3a
21
23
25
19
11
27
9
8
22
3
32
33
26
10
24
28
12
5
7
30
1
2

FIG. 5B

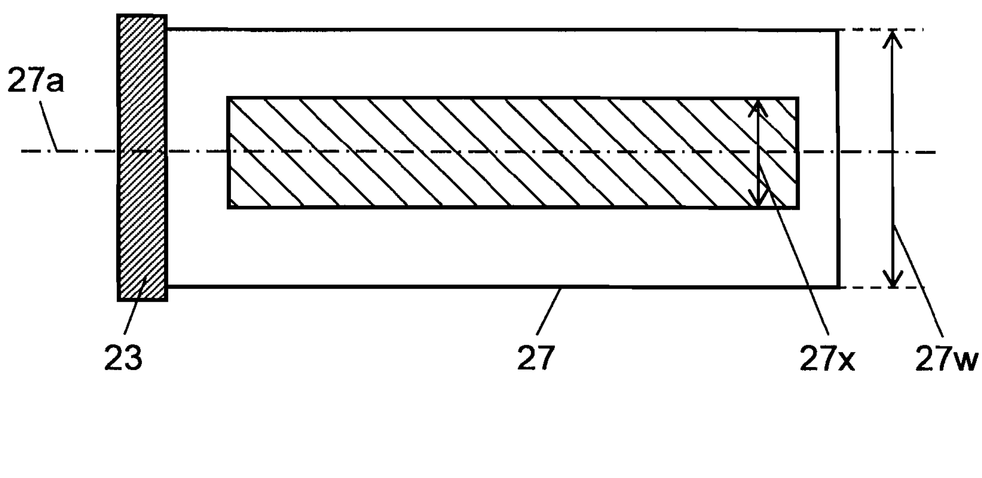

27a
23
27
27x
27w

FIG. 6

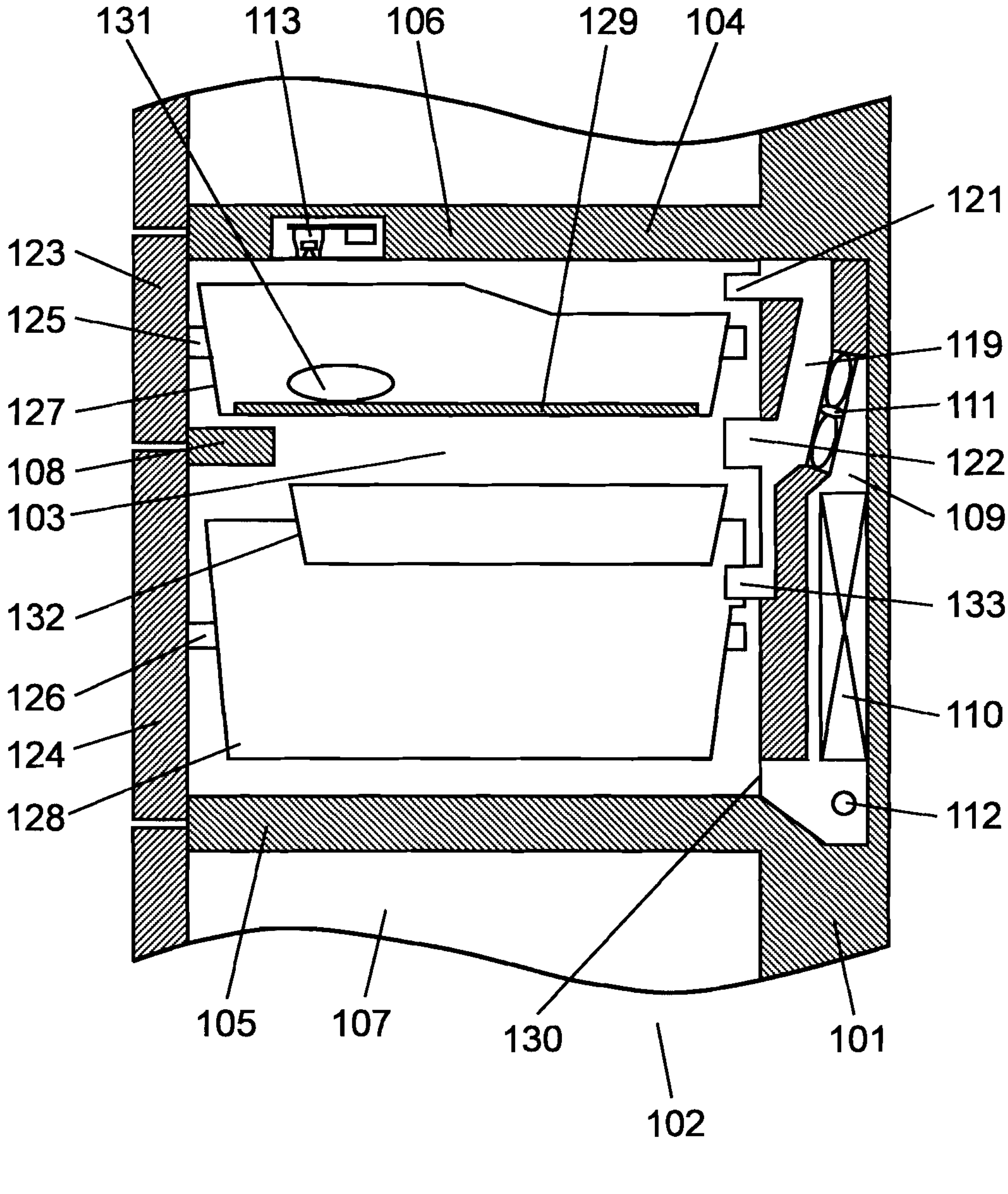

131
113
106
129
104
121
123
125
119
111
127
122
108
109
103
133
132
126
110
124
128
112
105
107
130
101
102

FIG. 7

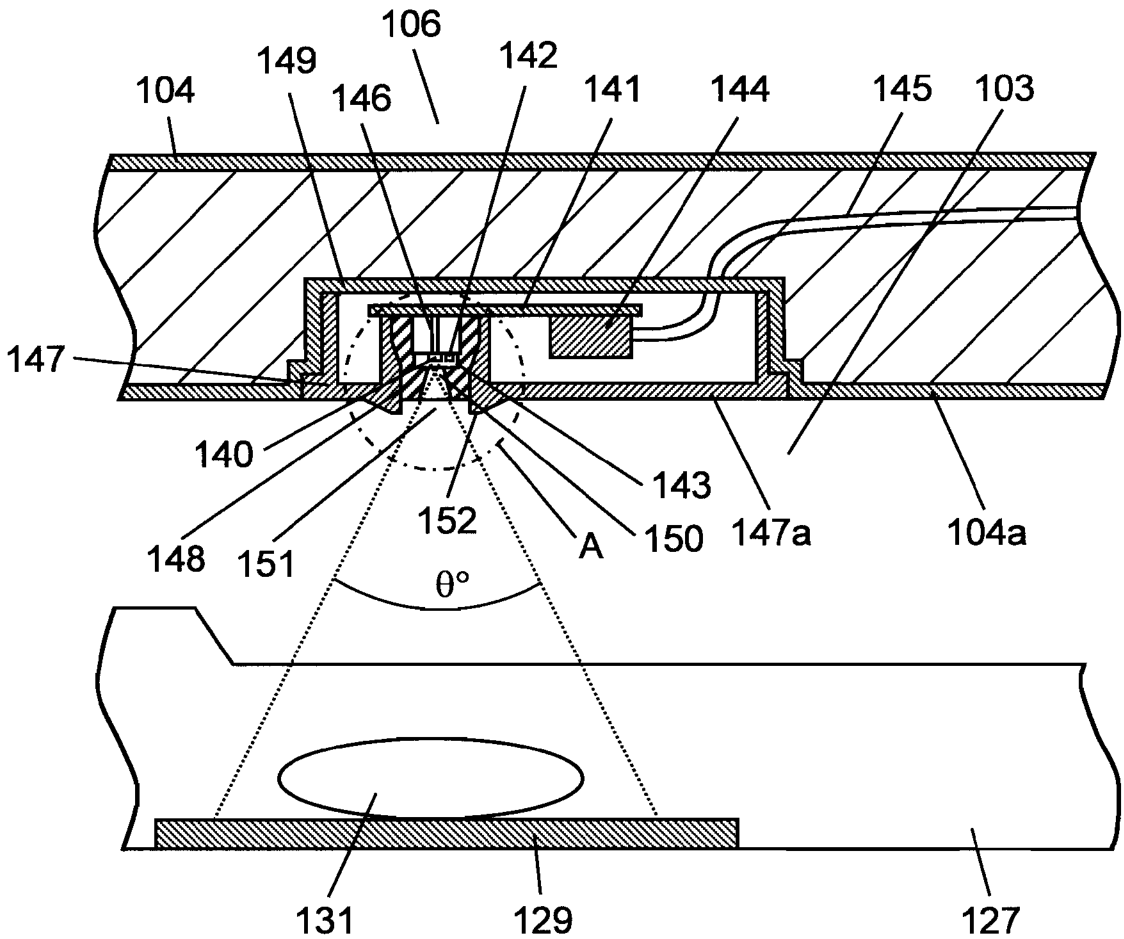

106
149
142
104
146
141
144
145
103
147
140
143
152
147a
104a
148
151
A
150
θ°
131
129
127

FIG. 8

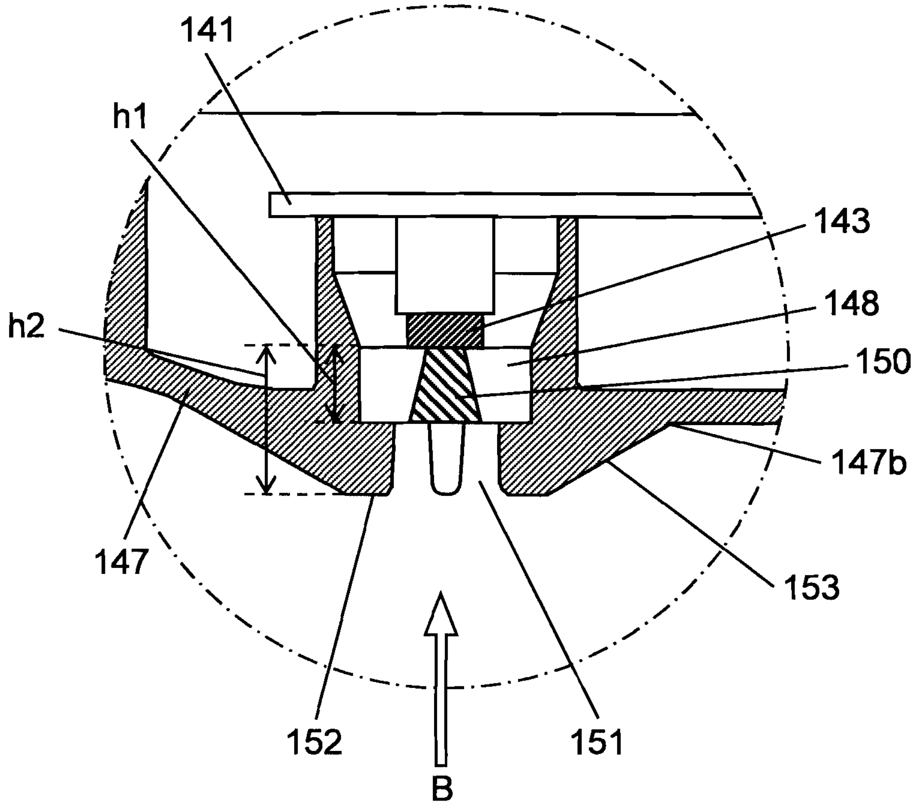

141
h1
h2
143
148
150
147b
147
153
152
151
B

FIG. 9

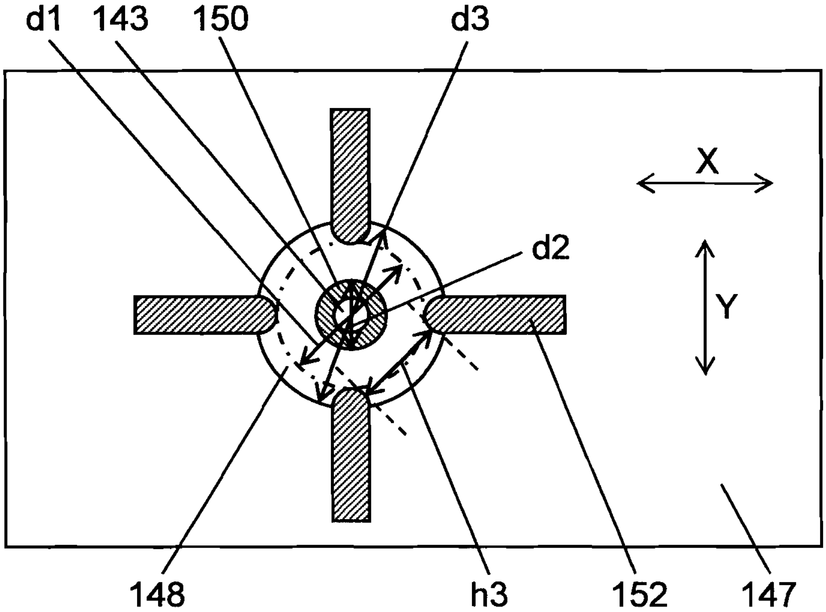

d1
143
150
d3
X
d2
Y
148
h3
152
147

FIG. 10

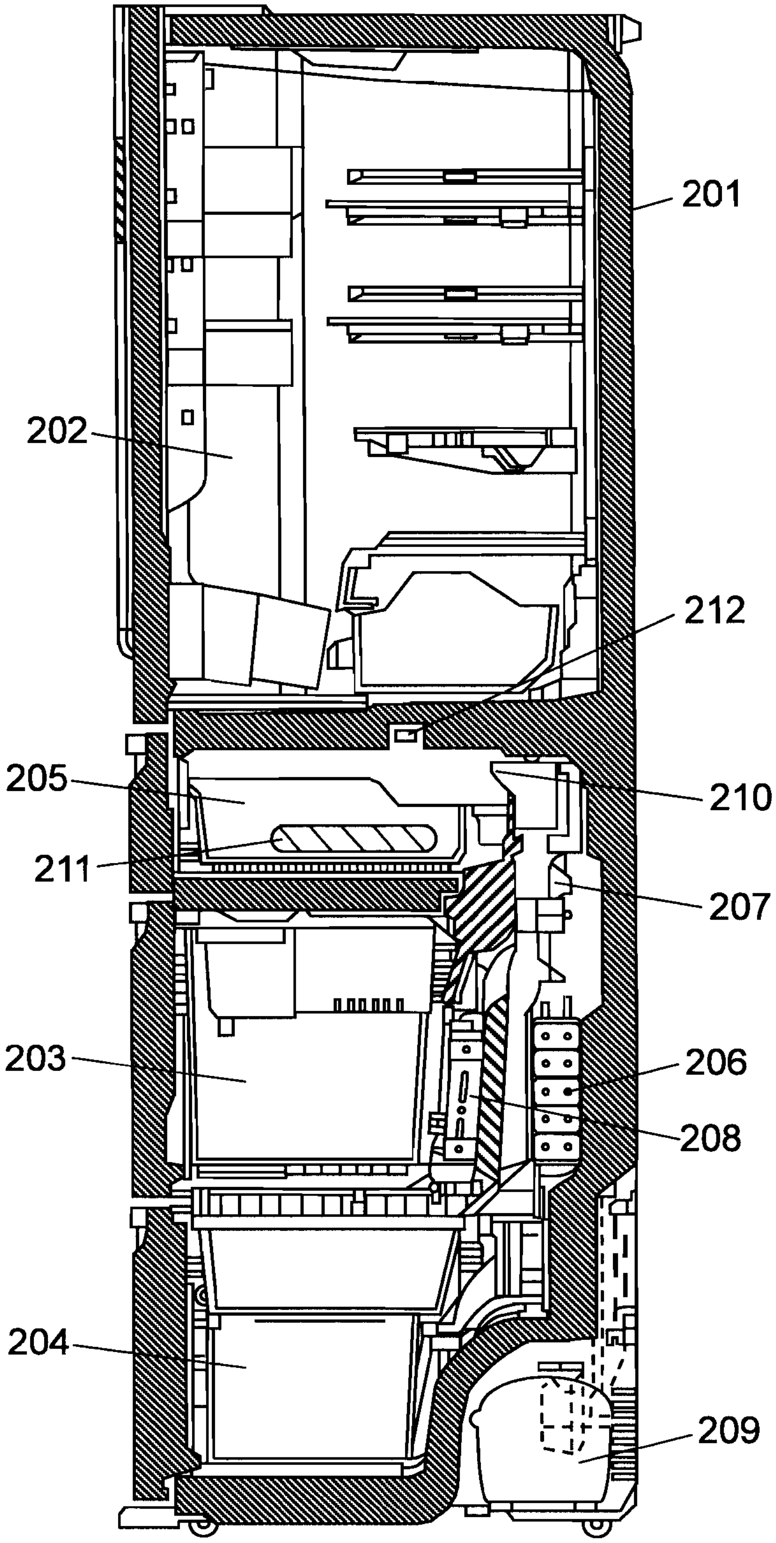


FIG. 11

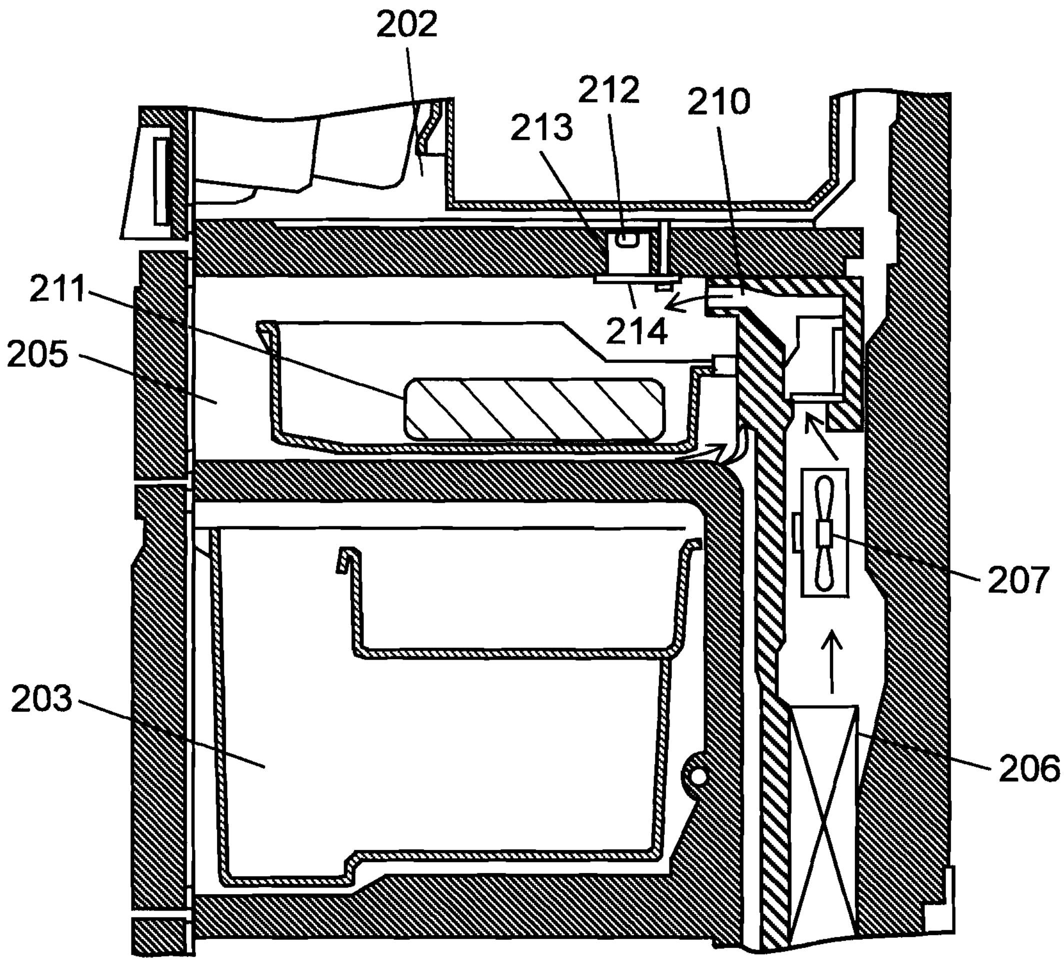


FIG. 12

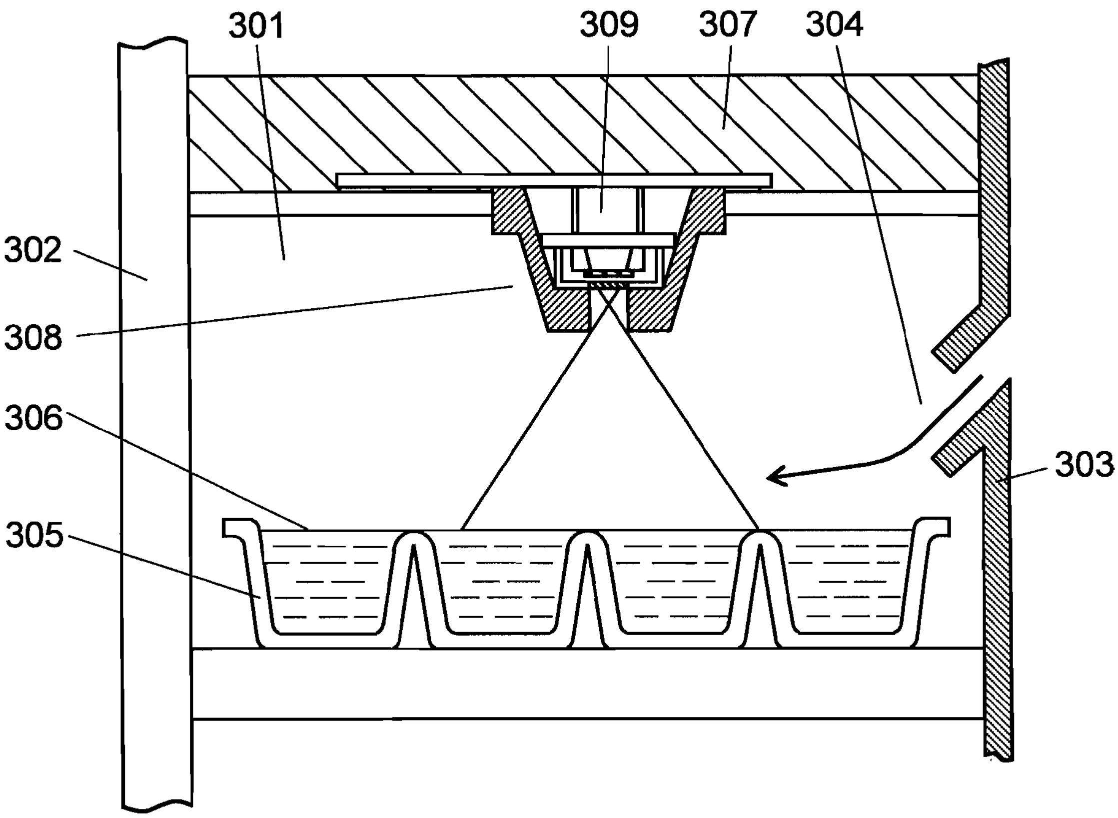
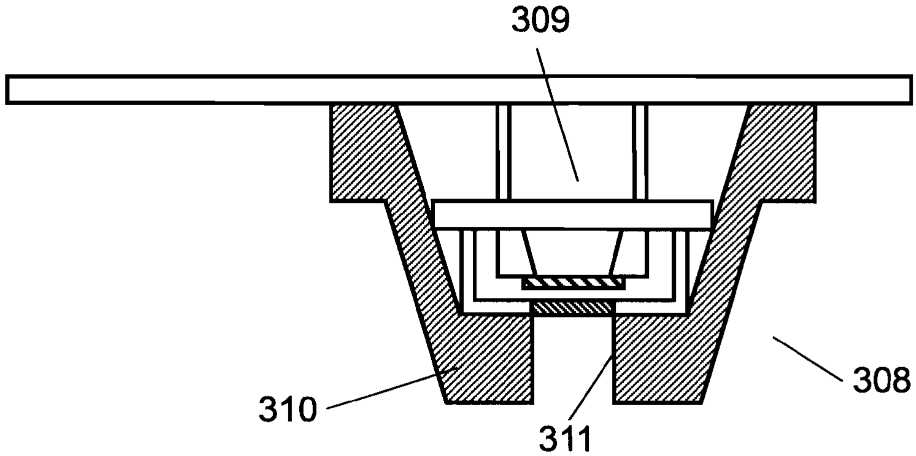



FIG. 13



## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001111

A. CLASSIFICATION OF SUBJECT MATTER
*F25D29/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25D29/00, G01J5/00, F24C7/08

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

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2009 |
| Kokai Jitsuyo Shinan Koho | 1971-2009 | Toroku Jitsuyo Shinan Koho | 1994-2009 |

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | JP 2002-228353 A (Toshiba Corp.), 14 August, 2002 (14.08.02), Claim 1; Par. Nos. [0013] to [0035]; Figs. 1, 3 (Family: none) | 1-9 |
| Y | JP 06-213724 A (Terumo Corp.), 05 August, 1994 (05.08.94), Claim 1; Par. Nos. [0004] to [0023]; Figs. 1 to 4 (Family: none) | 1-6 |
| Y | JP 2002-328291 A (Horiba, Ltd.), 15 November, 2002 (15.11.02), Par. Nos. [0015] to [0017]; Fig. 2 (Family: none) | 7-9 |

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

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

| | |
|---|---|
| Date of the actual completion of the international search<br>22 May, 2009 (22.05.09) | Date of mailing of the international search report<br>02 June, 2009 (02.06.09) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br>Facsimile No. | Authorized officer<br><br>Telephone No. |

Form PCT/ISA/210 (second sheet) (April 2007)

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2009/001111

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

The technical feature common to the inventions of claims 1-6 and the inventions of claims 7-9 relates to "a refrigerator including: an adiabatic basket configured by a plurality of adiabatic partitions; an adiabatic separation unit which partitions the adiabatic basket; a storage chamber separated by the partition unit; an infrared sensor having a temperature detection unit for detecting an emission amount emitted from an object stored in the storage chamber; and an infrared ray collecting member arranged in the infrared sensor."

(Continued to extra sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest** the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001111

Continuation of Box No.III of continuation of first sheet(2)

However, the search has revealed that the common technical feature is not novel since it is disclosed in JP 2002-2285353 A. As a result, the common technical feature makes no contribution over the prior art and cannot be a special technical feature within the meaning of PCT Rule 13.2, second sentence.

Consequently, it is obvious that the inventions of claims 1-6 and the inventions of claims 7-9 do not satisfy the requirement of unity of invention.

Form PCT/ISA/210 (extra sheet) (April 2007)

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description


- JP 2007212053 A **[0017]**
- JP 2006308504 A **[0017]**