



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.07.2012 Bulletin 2012/27

(51) Int Cl.:
F24C 7/06 (2006.01) H05B 6/12 (2006.01)

(21) Application number: **10811695.5**

(86) International application number:
PCT/JP2010/063556

(22) Date of filing: **10.08.2010**

(87) International publication number:
WO 2011/024645 (03.03.2011 Gazette 2011/09)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

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(30) Priority: **27.08.2009 JP 2009196435**

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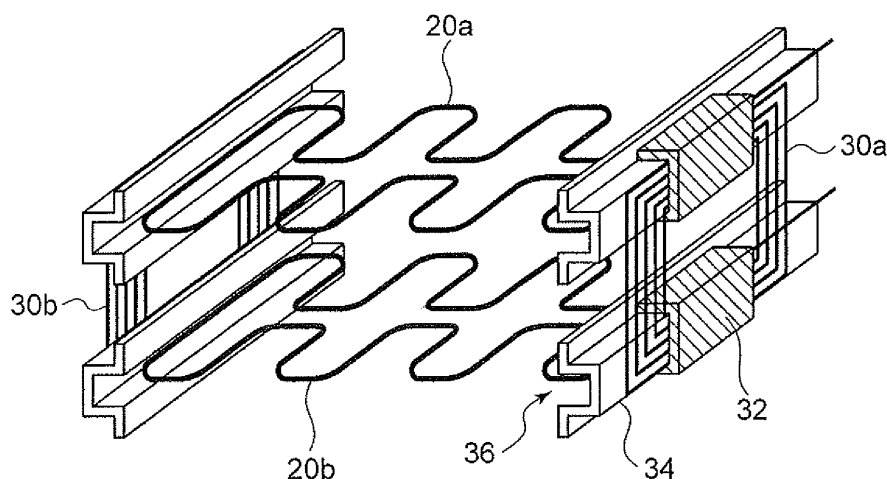
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(54) **HEATING DEVICE**

(57) A heating system of the present invention comprises a box-shaped heating chamber, a heater provided inside the heating chamber, the heater being made of conductive material in an electrical loop, a coil provided

outside the heating chamber, a power circuitry for supplying high-frequency current with the coil to generate high-frequency magnetic flux, and a magnetic member arranged so that the heater magnetically interlinks with the high-frequency magnetic flux generated by the coil.

Fig.2



Description

Technical Field

[0001] The present invention relates to a heating system, and in particular, relates to a heating cooker incorporating an induction current heater as a heat source in a heating box such as a heating oven, roaster, and grill.

Background Art

[0002] Many of heating cookers applying an electromagnetic induction heating principle, which are so-called IH (Induction-Heating) cookers, include, a heating box for cooking a grilled fish and the others. The heating box is generally named as a heating oven, roaster, or grill. A grilled fish (especially a saury grilled with salt, etc.) is popular when its surface is browned by radiation heat from burning heat source and its inside is well-heated within hot atmosphere.

[0003] While cooking the grilled fish such as the grilled saury, substantial amount of fat (combustible oil) comes out of the grilled fish. Therefore, it is required to provide a dish for receiving the fat, and to keep the dish and the fish fat therein at temperature lower than kindling temperature thereof for preventing the fish fat from burning within the heating box during cooking. This is not limited to the grilled fish, it is true while cooking meat as well. Such cooking is also referred to as a grill-cooking.

[0004] The heating box of the IH cooking heater is typically provided with upper and lower electrical heaters such as sheath heaters and radiant heaters, which may also be referred to as "resistive heaters" since they generate Joule heat when current flows through resistive elements. The electrical heaters are supplied with power through terminals electrically connected to a power source that is positioned outside the heating box, thereby generating Joule heat when electric power is supplied from the power source. The electrical heaters supplied with electric power transduce electric energy into thermal energy which heats and grills food to be cooked within the heating box directly and/or indirectly via heated atmosphere around the food. Such a heating cooker is incorporated not only within the IH cookers but also within a toaster oven and electric oven. While the heating cooker has a simple structure, it is difficult to clean inside the heating box because the electrical heaters are fixed within the heating box, and therefore it is required to improve the structure of the heating cooker to be more easily cleaned. Thus, in any types of heating systems including not only the IH cookers but also the heating ovens, the easy-to-clean feature is highly demanded, which is an essential demand for cookers of foods. In fact, many of heating ovens have been proposed so far, which has the heating source of metal for food which may be arranged within the heating box in a non-contact or induction manner, and/or detached from the heating box. **[0005]** For example, as disclosed in Patent Document 1 (JP

2003-282221 A), a conventional oven using the induction-heating technique includes upper and lower heating coils provided over and beneath the heating box made of magnetic material, and heats the heating box by supplying high-frequency current through the heating coils. The heating box can be detached from the oven, so as to make it easily cleaned. See Patent Document 1, paragraphs [0008]-[0009] and Fig. 2.

[0005] Also, according to another microwave oven using the induction-heating technique as suggested in Patent Document 2 (JP 08-138864 A), a heat-resisting insulating separator of heat-resisting glass is used for mechanically and electrically separating an induction-heating coil from the heating chamber, and a metal heated body is provided within the heating chamber over the separator, opposing to the heating coil. The heated body is formed as a metal band in a closed loop, and therefore, it can be designed to have induction current effectively generated, and area for radiation heat arbitrarily adjusted. The heated body is also structured to be detachably arranged within the heating chamber. See Patent Document 2, paragraphs [0024]-[0028] and Figs. 1, 3.

[0006] Further another microwave oven using the induction-heating technique as suggested in Patent Document 3 (JP 06-18044 A) includes induction-heating means for induction-heating peripheral portions (or left and right portions) of an oven dish which is detachably installed within the oven chamber. The oven dish includes a plate made of magnetic material such as iron plate having an enameled portion at least where the oven dish is heated. The induction-heating means includes a coil wound as a bobbin used in a sewing machine, and a core for effectively providing magnetic flux generated by the coil with the oven dish. The core is, for example, U-shaped, and the high-frequency magnetic flux forms a closed magnetic path through the core and the peripheral portion of the oven dish, rather than the other portions of the microwave oven. The oven dish is structured to have a lower portion of magnetic material such as magnetic stainless steel and an upper portion of highly heat-conductive material such as aluminum and copper. The magnetic material is induction-heated by the magnetic flux through the coil and the core, of which heat is eventually propagated to the oven dish of highly heat-conductive material. See Patent Document 3, paragraphs [0022], [0029]-[0036], and Figs. 1, 2, 5-7.

Summary of Invention

Problems to be solved by Invention

[0007] When the heating box or chamber using the above conventional induction-heating techniques is adapted into the IH cooking heaters for grill-cooking, a couple of following problems have been raised. In the conventional oven disclosed in Patent Document 1, a U-shaped magnetic body is inserted within the heating box and heated by induction current through the upper and

lower heating coils, and therefore, the lower surface of the magnetic body should be kept at temperature less than the kindling temperature (about 250 degrees C) of food fat (e.g., fish fat). Thus, since the lower surface of the magnetic body cannot be heated sufficiently, there is a problem that the oven is not suitable for grill-cooking by means of radiation.

[0008] In the conventional microwave oven disclosed in Patent Document 2, since the metal band is formed in a closed loop, effective induction-heating is achieved up to high temperature. However, when infrared radiation heat from the metal band is used for grill-cooking, the fat-receiving separator is to be provided between the metal band and the heating coil. It should be designed to have the magnetic flux run through the metal band to be heated but not through the fat-receiving separator. Thus, the fat-receiving separator is required to be made of insulating material such as ceramics. Yet, the ceramic separator should be thick enough to ensure mechanical strength, and also be spaced away sufficiently from the metal band to keep temperature of the separator less than the kindling point of the fat so as to prevent fat on the separator from burning. Thus, it is necessary to keep substantial gap or distance between the metal band and the fat-receiving separator, which raises another problem that the metal band cannot be efficiently heated by the heating coil.

[0009] Furthermore, the microwave oven disclosed in Patent Document 3 may be used with the oven dish for a frying-pan cooking, but not suitable for the grill-cooking although the oven dish may possibly be heated to generate radiation heat for the grill-cooking. However, the heating coils of the microwave oven suggested by Patent Document 3 may heat only the peripheral portions of the oven dish, and thus, the middle or central portion thereof is merely heated indirectly by heat transferred from the peripheral portions of the oven dish, which is made of highly heat-conductive material such as aluminum and copper. Therefore, it is required to make the highly heat-conductive material fairly thick in order to sufficiently heat the central portion of the oven dish. This causes drawbacks, in turn, such as reduction of space of the heating chamber and increase of heat capacity of the oven dish requiring substantial time to heat the oven dish.

[0010] The present invention addresses the above-mentioned drawbacks and has a purpose to realize a heating system which improves the easy-to-clean feature of the heating chamber with detachable heaters, and eliminates the problem of the food fat by arranging induction-heating means for heating the heaters outside the side walls of the heating chamber, also achieving substantially high temperature overall in the heating chamber.

Means for Solving Problems

[0011] In order to overcome the above-described drawbacks, one embodiment of the present invention is

to provide a heating system of the present invention comprises a box-shaped heating chamber, a heater provided inside the heating chamber, the heater being made of conductive material in an electrical loop, a coil provided outside the heating chamber, a power circuitry for supplying high-frequency current with the coil to generate high-frequency magnetic flux, and a magnetic member arranged so that the heater magnetically interlinks with the high-frequency magnetic flux generated by the coil.

Advantage of Invention

[0012] One embodiment of heating system according to the present invention generates induction current through a heater made of conductive material in an electrical loop, which generates Joule heat by induction current throughout the heater.

Brief Description of Drawings

[0013] Fig. 1 is a cross sectional view of the heating cooker according to the first embodiment of the present invention.

[0014] Fig. 2 is a perspective view illustrating an overall of main components of the heating cooker according to the first embodiment.

[0015] Fig. 3 is a perspective view illustrating the heat-insulating members of the heating cooker according to the first embodiment.

[0016] Fig. 4 is a perspective view schematically illustrating directions of coil current running through the coils of Fig. 2, and directions of induction current running through the heaters.

[0017] Fig. 5 is a partial enlarged cross sectional view of the induction-heating means according to the first embodiment.

[0018] Figs. 6A and 6B are plan views illustrating the heater of the heating cooker according to the first embodiment, in a structural and functional manner, respectively.

[0019] Fig. 7 is a cross sectional view of the heating cooker according to modification of the first embodiment, as similar to Fig. 1.

[0020] Fig. 8 is an enlarged cross sectional view of the induction-heating means according to modification of the first embodiment, as similar to Fig. 5.

[0021] Fig. 9 is a cross sectional view of the induction-heating means used in an experiment of the first embodiment.

[0022] Fig. 10 is a plan view of the induction-heating means used in an experiment of the first embodiment, showing several measurement points of the heater.

[0023] Fig. 11 is a graph showing increased temperature measured at each of the measurement points of the heater in the experiment.

[0024] Fig. 12 is a cross sectional view of the heating cooker according to the second embodiment of the present invention.

[0025] Fig. 13 is a perspective view illustrating an overall of main components of the heating cooker according to the second embodiment.

[0026] Fig. 14 is a graph showing increased temperature of the heater measured in the experiment according to the second embodiment.

[0027] Fig. 15 is a cross sectional view of the heating cooker according to modification of the second embodiment.

[0028] Fig. 16 is a chart showing a relationship between increased temperature of the heater and length of the magnetic member according to modification of the second embodiment.

[0029] Fig. 17 is a perspective view illustrating an overall of main components of the heating cooker according to further modification of the second embodiment.

[0030] Fig. 18 is a cross sectional view of the heating cooker according to the third embodiment of the present invention.

[0031] Fig. 19 is a perspective view illustrating an overall of main components of the heating cooker according to the third embodiment.

[0032] Fig. 20 is a partial enlarged cross sectional view of the induction-heating means according to the third embodiment.

[0033] Fig. 21 is an enlarged cross sectional view of the induction-heating means according to modification of the third embodiment as similar to Fig. 20.

[0034] Fig. 22 is an enlarged cross sectional view of the induction-heating means according to further modification of the third embodiment as similar to Fig. 20.

[0035] Fig. 23 is a cross sectional view of the heating cooker according to the fourth embodiment of the present invention.

[0036] Fig. 24 is a perspective view illustrating an overall of main components of the heating cooker according to the fourth embodiment.

[0037] Fig. 25 is a cross sectional view of the heating cooker according to modification of the fourth embodiment.

[0038] Figs. 26A and 26B are cross sectional views of the heating cooker according to the fifth embodiment, with the movable component being in closed and opened positions to the stationary component, respectively.

[0039] Fig. 27 is a perspective view illustrating the induction-heating means according to the fifth embodiment.

[0040] Fig. 28 is an enlarged cross sectional view of the induction-heating means according to the fifth embodiment, taken along a line of A-A of Fig. 27.

[0041] Fig. 29 is a cross sectional view of the heating cooker according to the sixth embodiment of the present invention.

[0042] Fig. 30 is a perspective view illustrating an overall of main components of the heating cooker according to the sixth embodiment.

[0043] Fig. 31 is a perspective view illustrating an overall of main components of the heating cooker according

to modification of the sixth embodiment.

[0044] Fig. 32 is a perspective view illustrating an overall of main components of the heating cooker according to further modification of the sixth embodiment.

5 **[0045]** Fig. 33 is a perspective view of an overall of the plate-like lower heater according to further modification of the sixth embodiment.

[0046] Fig. 34 is a cross sectional view of the plate-like lower heater of Fig. 33.

10 **[0047]** Fig. 35 is a perspective view illustrating an overall of main components of the heating cooker according to further modification of the sixth embodiment.

[0048] Fig. 36 is a development view of the heater of the heating cooker of Fig. 35.

15 **[0049]** Fig. 37 is a cross sectional view of the heater of the heating cooker of Fig. 35.

[0050] Fig. 38 is a cross sectional view illustrating an overall of main components of the heating cooker according to further modification of the sixth embodiment.

20 **[0051]** Fig. 39 is a cross sectional view illustrating an overall of main components of the heating cooker according to further modification of the sixth embodiment.

Description of Reference Numerals

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[0052] 1: heating cooker (heating system), 10: heating chamber (box-shaped housing), 12a: upper wall, 12b: lower wall, 16: front wall, 18: rear wall, 20: heater, 22: low-resistive part, 24: power-supplied part, 25: cooling part, 26: high-resistive part (heating part), 30: coil, 32: magnetic member, 34: heat-insulating member, 36: groove (opening), 37: grid, 38: fat-receiving dish, 40: base portion, 42: side portion, 44: extended portion, 45: heat-insulating member, 50: stationary component, 52: movable component, 54: heater-access port, 56: airtight case, 58: lower heater, 59: cutout, 70: box-shaped airtight container, 72: lid member, 74: container member, 75: container body, $\phi 1$, $\phi 2$: magnetic flux.

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Description of Embodiments

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[0053] The present invention relates to any types of heating systems and may be applicable even for an industrial firing furnace and drying furnace, and a household cooker as well. Referring to attached drawings, embodiments of a cooker as an example of the heating system according to the present invention will be described herein. In the description, a couple of terms for indicating the directions (for example, "upper", "lower", "left" and "right", etc.) are conveniently used just for facilitating clear understandings, it should not be interpreted that those terms limit the scope of the present invention. Similar components are denoted with similar reference numerals throughout the description.

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[0054] Embodiment 1. Fig. 1 is a cross sectional view of the heating cooker 1 according to the first embodiment, and Fig. 2 is a perspective view schematically illustrating an overall of main components of the heating cooker of

Fig. 1. The heating cooker 1 is suitably used for an IH cooking heater, especially useful as a heating chamber for grill-cooking. Also, the present invention may also be adapted for any other types of heating cookers such as a microwave oven and/or a toaster oven, which is used for various cookeries such as oven-cooking, as well as grill-cooking.

[0055] The heating cooker 1 according to the first embodiment of the present invention includes a heating chamber (box-shaped housing) 10 as illustrated in Figs. 1, 2. The heating chamber 10 includes upper and lower walls 12a, 12b, right and left side walls 14a, 14b extending vertically, and front and rear side walls (not shown). Also, the heating cooker 1 includes detachable heaters 20a, 20b formed of metal in a closed loop (in a closed electrical circuit) provided within the heating chamber 10 near to the upper and lower walls 12a, 12b. It also includes coils 30a, 30b provided along the right and left side walls 14a, 14b of the heating chamber 10, and a pair of magnetic members 32 of magnetic material such as ferrite core provided along and adjacent the coils 30a, 30b.

[0056] Each of the coils 30a, 30b may be formed, for example, by twisting a plurality (nineteen) of copper wires having diameter of 0.3mm coated with resin wire (so called a litz wire), and by winding the litz wire a plurality of times (25 times) in parallel with the side walls 14a, 14b in a rectangular shape each of which corner is bent in a right curved or an elliptic shape. In the litz wire wound along the sides of the rectangular shape of the coil, current (magnetic flux) runs through the same direction. As shown in Fig. 2, each of the magnetic members 32 is formed in a U-shaped so as to cover or surround the litz wires, and is arranged to oppose the upper and lower heaters 20a, 20b.

[0057] The magnetic members 32 may be made of magnetic material similar to one generally used as the ferrite core around the heating coil of a typical IH cooking heater. Also, a plurality of U-shaped heat-insulating members 34 are provided inside each of the U-shaped magnetic members 32. Thus, the coils 30a, 30b are intervened between the magnetic members 32 and the heat-insulating members 34 at least in portions where the coils oppose to the heaters 20a, 20b, as illustrated in Figs. 1 and 2. Furthermore, the heat-insulating members 34 may have a double-layered structure having a heat-insulating layer 34a made of glass wool or ceramic wool and a ceramics layer 34b as shown in Fig. 3, and a portion of the side walls 14a, 14b of the heating chamber 10 may be formed of ceramics or metal such as iron and stainless steel.

[0058] The heat-insulating members 34 so structured thermally insulates the coils 30a, 30b and the magnetic members 32 from hot atmosphere within the heating chamber 10. Besides, the insulating layer 34a is formed as air gap or air stream. Portions of the side walls 14a, 14b may be composed of the heat-insulating members 34 and the magnetic members 32 together with the coils

30a, 30b as illustrated in Fig. 1. The other portions of the walls composing the heating chamber 10 (e.g., upper and lower walls 12a, 12b) are made of metal such as iron and stainless steel or insulating heat-resisting material such as ceramics and glass. Although not shown, the heating chamber 10 is defined also by the front and rear walls. Thus, the heating chamber 10 is formed as a closed box or housing from the upper and lower walls 12a, 12b, side walls 14a, 14b, and the front and rear walls. The front wall has a front door (not shown) that can be opened and closed for accessing food inside the heating chamber 10.

[0059] The heaters 20a, 20b are inserted and supported within grooves (openings) 36 of the heat-insulating members 34, each of which extends horizontally as shown in drawings. Thus, the heaters 20a, 20b are merely situated or seated on the grooves 36, which allows the heaters to be detachable from the front door. Also, this structure of the heating chamber 10 allows both of a grid 37 for supporting food and a fat-receiving dish 38 for receiving food fat to be inserted in and/or detached from the heating chamber 10 through the front door. The grid 37 and the fat-receiving dish 38 may be made of material and be structured in any configurations used in the heating chamber 10 of a conventional IH cooking heater. Also, the side walls 14a, 14b and the other walls of the heating chamber 10 may preferably have inner surfaces coated with suitable material for various purposes realizing an antifoulant effect and an infrared-ray effect.

[0060] Next, the operation of the heating cooker 1 will be described herein. When the high-frequency current having frequency in a range of 20kHz through 100kHz is supplied with coils 30a, 30b from a power circuitry (not shown), a high-frequency magnetic field is generated by and around the coils 30a, 30b. The high-frequency magnetic flux generated by the coils 30a, 30b defines a magnetic loop running through the U-shaped magnetic members 32, the heaters 20a, 20b, and the grooves (openings) 36 of the heat-insulating members 34. Thus, the heaters 20a, 20b magnetically interlinks with the high-frequency magnetic flux. Then, induction current is generated through each of the heaters 20a, 20b that is electrically closed or formed as a loop, and then Joule heat is to be generated by the induction current, so that the heaters 20a, 20b are heated entirely and uniformly. Such entire and uniform heating by the heaters 20a, 20b heats the food received within heating chamber 10 in an even manner. When the power circuitry supplies sufficient power (e.g., 2kW in total) with the coils 30a, 30b, the heaters 20a, 20b are heated over 800 degrees C, from which infrared energy is radiated to directly heat the food. Also, the heaters 20a, 20b heats peripheral atmosphere which is distributed by convection throughout the heating chamber 10, and then indirectly heats the food in hot atmosphere. As above, the food within the heating chamber 10 is heated by infrared radiation and hot atmosphere, for grill-cooking.

[0061] Fat flowing from the food to be heated is re-

ceived by a fat-receiving dish 38 provided beneath the lower heater 20b. According to the present invention, in principle, the induction current runs through the looped lower heater 20b, thereby generating Joule heat. This is the heating principle different from that of the conventional heating cooker as disclosed in the above Patent Documents 1, 2, where the magnetic body is directly induction-heated. Therefore, even if the fat-receiving dish 38 is made of metal and arranged beneath the lower heater 20b, it is not directly induction-heated by the lower heater 20b, and therefore, the fat-receiving dish 38 can be kept at temperature much lower than the kindling temperature of the fat, by spacing the gap between the lower heater 20b and the fat-receiving dish 38.

[0062] As above, according to the present invention, the heating principle utilizing Joule heat generated by the induction current running through the looped heater is different from the "induction--heating" principle for pans seated on the top plate of a typical IH cooking heater, and thus, the heating principle the present invention may not be referred to as the "induction-heating". However, since the present invention utilizes Joule heat generated by the "induction current" running through the looped heater caused by the "electromagnetic induction", this application will also use the term of the "induction-heating" herein. Also, the coils 30a, 30b and the magnetic members 32 are collectively referred to as "induction-heating means" for generating induction current through the heaters 20a, 20b. It should be noted that the temperature and the input power of the heaters 20a, 20b are indicated above as an example, and the temperature of the heaters 20a, 20b may be determined by parameters including the input power and the radiation surface area thereof, etc.

[0063] Although not described in detail, any types of power circuitries may be incorporated which are similar to ones used in a typical induction-heating cooker such as a IH cooker, including, for example, a half-bridge circuitry, a full-bridge circuitry, and an one-oscillator circuitry. As easily be configured for a person skilled in the art without further description of the power circuitry in the embodiments, an oscillating capacitance is connected with the coil in series used in the half-bridge circuitry and the full-bridge circuitry, and in parallel used in the one-oscillator circuitry. This is well known in the art, and therefore is also adapted in other embodiments according to the present invention. Also, it should be noted that each of the coils 30a, 30b is supplied with power individually from the respective one of the power circuitries, or the coils 30a, 30b connected in parallel or series with each other may be supplied with power from the same the power circuitry. When the coils 30a, 30b are connected in parallel or in series with each other, attention should be paid for connection thereof, taking into consideration of current flow direction, which will be discussed more hereinafter.

[0064] Fig. 4 illustrates directions of coil current running through the coils 30a, 30b, directions of magnetic

flux generated by coil current, and directions of induction current running through the heaters 20a, 20b induced by electromagnetic induction. For facilitating understandings, all of components except the coils 30a, 30b and the heaters 20a, 20b are eliminated. In Fig. 4, flow directions of the coil current and the induction current are traced over the coils 30a, 30b and the heaters 20a, 20b. The coil current and the induction current have flow directions alternated at driving frequency, and Fig. 4 is illustrated at a certain moment of the flow directions. As illustrated in Fig. 4, the coil current through the coils 30a, 30b generates the magnetic flux around the coils 30a, 30b with which heaters 20a, 20b magnetically interlink, thereby developing electromotive force and generating the induction current through the heaters 20a, 20b formed in a closed loop. Thus, this mechanism is the same as one of a transformer, in which the coils 30a, 30b may be regarded as being equivalent to primary coils, and so the heaters 20a, 20b being as secondary coils of the transformer. Since the heaters 20a, 20b are heated by using such mechanism, when the coils 30a, 30b connected in series or in parallel are driven by a single power circuitry, the coils 30a, 30b should be connected so as to allow the coil current running as shown in Fig. 4. On the other hand, when each of the coils 30a, 30b is driven individual power circuitries, the phase (or direction) of the coil current through the coils 30a, 30b may be adjusted for obtaining any desired (or controllable) heating efficiency, and may be set optimal for realizing the most heating efficiency when the phase (or direction) is controlled as shown in Fig. 4.

[0065] Fig. 5 is an enlarged cross sectional view of one of four induction-heating means of the heating cooker 1 in Fig. 1, which includes the coil 30 and the magnetic member 32 (together with the heat-insulating members 34 and the heater 20). In Fig. 5, the heater 20 is illustrated only for a portion which magnetically interlinks with the magnetic flux. As the high-frequency current runs through the coil 30, the high-frequency magnetic flux is generated around the coil 30. The high-frequency magnetic flux runs through a magnetic circuit (loop) which penetrates the U-shaped magnetic member 32 and transverses the U-shaped opening thereof. In this context, the "U-shaped magnetic member 32" is defined as including a base portion 40 extending along the coil 30, and a pair of side portions 42a, 42b extending perpendicularly to the base portion 40 from ends thereof, between which the opening 36 is formed.

[0066] The magnetic flux extending across the opening 36 of the U-shaped magnetic member 32 includes one ($\phi 1$) that does not pass through the heater 20 and another one ($\phi 2$) that penetrate the heater 20. While the magnetic flux ($\phi 1$) is quite effective in generating the induction current through the electrically looped heater 20, the magnetic flux ($\phi 2$) is less effective because its magnetic energy is used mostly for generating eddy current within the portion where the magnetic flux is penetrated but few for generating the induction current throughout

the looped heater 20. Thus, the heater 20 is heated by Joule heat caused by the induction current and the eddy current as well. Therefore, since the heater 20 is made of uniform material and shaped as having the same section along its extending direction, in general, it has higher temperature at portions which are closer to and magnetically interlinked with the coils 30a, 30b, and lower temperature at the other portions. The magnetic energy of the magnetic flux (ϕ_2) closer to the coils 30a, 30b also contributes heating atmosphere within the heating chamber 10 without energy loss, however, this requires further improvement of thermal insulation between the coil 30 (and the magnetic member 32) and the heater 20, by providing air gap for circulating air therethrough and/or by designing the heat-insulating member 34 thicker for thermally protecting the coil 30.

[0067] Figs. 6A and 6B are plan views of the heater 20 suitably used in the heating cooker 1 of the first embodiment. The heater 20 is illustrated structurally in Fig. 6A and functionally in Fig. 6B. It should be noted that the heater 20 used for the heating cooker 1 of the present invention is not limited thereto, and may be formed in any shape and configuration with any material as far as being shaped in an electrically closed loop. Preferably, the heater 20 may be composed of two parts structurally different from each other. That is, the heater 20 may include low-resistive parts 22 having lower electrical resistance at the end regions adjacent the coils 30a, 30b, and high-resistive parts 26 having higher electrical resistance in the middle thereof. The terms, i.e., the "low-resistive" part and the "high-resistive" part are intended as having lower or higher electrical resistance per unit length relative to each other. For example, when using the same metal for both parts 22, 26, the low-resistive part 22 and the high-resistive part 26 may be formed from a solid bar and a hollow pipe, respectively, and may be connected, e.g., by welding each other. Also, when using different metal for each part 22, 26, the low-resistive part 22 may be made of lower specific resistance such as copper and the high-resistive part 26 may be made of higher specific resistance such as stainless steel. Also, the low-resistive part 22 and the high-resistive part 26 may have structure and material different from each other. For example, the low-resistive part 22 may be made from a solid bar of copper or copper alloy having diameter of 6mm, and the high-resistive part 26 may be made of hollow pipe of stainless steel having diameter of 6mm and radial thickness in a range between 0.3mm through 1mm, which are connected together by welding or gluing. It should be noted that since the terms, i.e., "specific resistance" is referred as one at a give high frequency of the induction current through the heater 20, the hollow bar may possibly have the specific resistance less than that of the solid due to the skin effect, and if this is the case, the low-resistive part 22 may be made of hollow pipe.

[0068] Since the heater 20 includes no electrical core like a heating wire of a sheath-heater, the heater 20 may be formed in any configuration as shown in Figs. 6A and

6B at a reasonable cost without damage by being folded. Furthermore, the heater so structured may be coated with various material for antifouling and/or protecting effect.

[0069] The heater 20 will be described in a functional aspect herein. The low-resistive part 22 shown in Fig. 6B is composed of a power-supplied part 24 and a cooling part 25. The high-resistive part 26 shown in Fig. 6A is also referred to as a heating part 26.

[0070] Next, operation thereof will be explained herein. As above, the heater 20 includes the low-resistive part 22 composed of the power-supplied part 24 and the cooling part 25 both made of a solid copper bar, and the high-resistive part (heating part) 26 of a stainless pipe. As illustrated in Figs. 1 and 2, the heater 20 is inserted into the grooves (openings) 36 of the heat-insulating members 34 and situated within the heating chamber 10. When the coil 30 is supplied with high-frequency current by the power circuitry, high-frequency magnetic flux is generated around the coil 30, which magnetically interlinks with the power-supplied part 24 so as to generate induction current through the heater 20. Then, while the power-supplied part 24 is heated in response to Joule heat caused by induction current and eddy current, as it has relative lower resistance, less Joule heat by the induction current is generated therein. Also, as the power-supplied part 24 is made of material having relative low resistance, such as nonmagnetic metal (e.g., copper), it is possible to sufficiently reduce Joule heat by the eddy current.

[0071] Since the power-supplied part 24 is situated within or surrounded by the groove 36 of the heat-insulating member 34, it is less cooled than the cooling part 25. Although the cooling part 25 has the same structure and construction material as the power-supplied part 24, since the cooling part 25 is surrounded by air, it is much more cooled than the power-supplied part 24. Also, the cooling part 25 is made of material having less resistance, Joule heat by induction current is reduced and kept at relative lower temperature.

[0072] Meanwhile, the heating part 26 is overall exposed in the air, it is cooled equally as the cooling part 25, however, since the heating part 26 has greater electronic resistance, it generates more Joule heat by induction current than the cooling part 25. Therefore, the food within the heating chamber is efficiently heated and grilled by radiation heat from the heating part 26. Also, the cooling part 25 generates less heat and radiates more heat transferred from the heating part 26 to peripheral air, which minimizes the heat that is generated by the heating part 26 and transferred through the cooling part 25 to the power-supplied part 24, thereby keeping the power-supplied part 24 at lower temperature.

[0073] Next described herein is the magnetic member 32 defining the magnetic loop (magnetic circuit). As shown in Fig. 5, the high-frequency current through the coil 30 generates the high-frequency magnetic flux around the coil 30 which defines the magnetic circuit running through the U-shaped magnetic member 32 and

across the opening 36. As above, while the magnetic flux (ϕ_2) penetrates through the heater 20 but the magnetic flux (ϕ_1) does not, both of the magnetic flux generate induction current running through the heater 20. In order to obtain greater induction current through the heater 20, preferably the magnetic flux (ϕ_1) is increased as much as possible. Also in order to reduce Joule heat by the eddy current in the power-supplied part 24, it is desirable to reduce the magnetic flux (ϕ_2), thereby to increase the ratio of the magnetic flux (ϕ_1) over the magnetic flux (ϕ_2).

[0074] Fig. 7 is a cross sectional view of an improved heating cooker 1, which is generally similar to that as illustrated in Fig. 1, except that the magnetic member 32 has a different shape and/or configuration. Fig. 8 is an enlarged cross sectional view of a portion of the induction-heating means, similar to Fig. 5, which includes the coil 30, the magnetic member 32, the heat-insulating members 34, and the heater 20. The magnetic member 32 of Fig. 8 is basically the same as that of Fig. 5 except its shape and/or configuration so that the magnetic member 32 is improved to increase a ratio (ϕ_1/ϕ_2) of the magnetic flux.

[0075] While the magnetic member 32 of Fig. 5 has a U-shaped cross section, the magnetic member 32 of Figs. 7 and 8 has a C-shaped cross section. In this application, the "C-shaped magnetic member" are intended as one including a base portion 40 extending along the coil 30, a pair of side portions 42a, 42b extending perpendicularly to the base portion 40 from the ends thereof, and a pair of extended portions 44a, 44b extending from tips of the side portions 42a, 42b towards each other, between which the opening 36 is formed. Thus, the magnetic member 32 of Fig. 8 has a cross section which has a rectangular shape having one member partially opened or broken in its middle. The magnetic member 32 may have a trapezium or oval shape rather than the rectangular shape.

[0076] As illustrated in Figs. 7 and 8, the C-shaped magnetic member 32 reduces magnetic resistance of the magnetic flux (ϕ_1), thereby increasing the magnetic flux (ϕ_1) between the extended portions 44a, 44b and reducing the magnetic flux (ϕ_2). Therefore, the C-shaped magnetic member 32 of Figs. 7 and 8 reduces Joule heat by eddy current within the power-supplied part 24 of the heater 20, in comparison with the U-shaped magnetic member 32 of Fig. 5. Thus, it is preferred to design the magnetic member 32 in the C-shaped configuration. Yet, in case where the groove (opening) 36 has the same width, the C-shaped magnetic member 32 requires greater volume of construction material than the U-shaped magnetic member 32, and therefore, raises manufacturing cost of the C-shaped magnetic member 32. Furthermore, as discussed above, in order to keep the power-supplied part 24 at lower temperature, the power-supplied part 24 and the heating part 26 of the heater 20 may not necessarily be structured or formed in a different manner, so that the manufacturing cost of the heater 20 is substantially reduced. In other words, upon taking con-

sideration of the other design factors such as the manufacturing cost, it is to be determined whether the U-shaped or C-shaped magnetic member 32 is incorporated.

[0077] It is more preferable that the C-shaped magnetic member 32 has the smaller opening 36 (less distance between the extended parts 44a, 44b), and it is ultimately or most desirable that the distance between the extended parts is zero and the magnetic member 32 has an O-shaped cross section. However, if the magnetic member 32 is designed to be O-shaped, the heater 20 cannot be detached out of the magnetic member 32, and therefore, another innovated structure is required to have the heater 20 detachable. Also in order to have the opening 36 of the magnetic member 32 smaller, the heater 20 may be formed from a metal plate instead of a bar or pipe having a circular cross section. For example, the heater 20 made of non-magnetic stainless steel plate having thickness of 2mm may cause the opening 36 (the distance between the extended parts) of the C-shaped magnetic member 32 to be smaller by 4mm.

[0078] Next, an experimental result will be described herein. When supplying the coils 30a, 30b of the heating cooker 1 as structured in Fig. 2 with the high-frequency current, the temperature of the heaters 20a, 20b were measured. The upper wall 12a and the front wall of the heating chamber 10 of Fig. 2 were kept opened in this experiment. This is because the temperature of the heaters 20a, 20b was detected directly by a thermocouple, and the heating chamber 10 was to be prevented from being overheated. Fig. 9 is a cross sectional view of the induction-heating means of the heating chamber 10 used in the experiment, in which the scale size thereof was almost precisely duplicated as actually used one. The magnetic member 32 has the C-shaped cross section as shown in Fig. 9 and the length of 60mm along the direction of depth in the drawing. The magnetic member 32 is made from ferrite core and has thickness of 5mm. The heat-insulating member 34 is made of ceramic wool and has thickness of 10mm. The coil 30 was formed by 25 times winding the litz wire of nineteen of twisted copper wires having diameter of 0.3mm coated with resin wire. The coils 30a, 30b provided at left and right side walls of the heating chamber 10 as shown in Fig. 2, were connected in parallel and supplied with the high-frequency current of 25kHz from a half-bridge power circuitry. The heater 20 has a circular cross section having diameter of 6mm. As seen from Fig. 9, the heater 20 is positioned close to the opening 36 of the U-shaped magnetic member 32, and therefore, there seems insufficient magnetic flux (ϕ_1) which passes by (or does not penetrate through) the heater. Fig. 10 shows the structure of the heater 20 used in the experiment, in which the scale size thereof was almost precisely duplicated as actually used one. The heater 20 was made to have two different types of material and configuration also as shown in Fig. 6. In Fig. 10, the low-resistive part 22 was made from a bar of copper having diameter of 6mm and the high-resistive part

26 was made from a hollow pipe of non-magnetic stainless steel SUS 304, which has outer diameter of 6mm, inner diameter of 4mm, and radial thickness of 1mm. The copper bar (low-resistive part 22) and the stainless pipe (high-resistive part 26) were connected by gold soldering. A pair of portions as shown by left and right dashed rectangles in Fig. 10 is inserted in the grooves 36 of the heat-insulating members 34 when situated within the heating chamber 10. Thus, the heater 20 so structured includes no cooling part 25 as shown in Fig. 6B. Several points where the thermoelectric couples were provided for thermal measurements are indicated by solid circles A-D on the heater 20 of Fig. 10. The thermoelectric couples were attached by winding a Kapton tape on those points. Because of the thermally resisting limit of the Kapton tape, the temperature was measured in a range less than 400 degrees C.

[0079] Fig. 11 is a graph showing temperature detected at each of the temperature measurement points of the heater 20 when the power circuitry is supplied with power of 1kW. The temperature measurement were made on the upper heater 20a at the points A, B, C, D in Fig. 10, and on the lower heater 20b at the points A, B, C. The denotation of "power-supplied parts" in Fig. 11 indicates the temperature detected at the points A, B, and the denotation of "heating parts" in Fig. 11 indicates the temperature detected at the points C, D. Temperature on the upper and lower heaters 20a, 20b detected at each of the points are approximately the same as one another, those measurements are plotted in Fig. 11 without distinguishing the upper or lower heater 20a, 20b.

[0080] As clearly shown in Fig. 11, the heating cooker 1 having the heater 20 of Fig. 2 is used for heating and cooking food. Since the heating part 26 of the heater 20 at each measurement point has approximately the same temperature, it is clear that the heating part 26 is heated by Joule heat caused by induction current running throughout the looped heater 20. The thermal increase rate of the heating part 26 is substantial, which is partially because of less heat capacity of the heating part 26 made of a stainless pipe. For example, two minutes after initiating heating, the temperature of the heating parts 26 is rather higher than that of the power-supplied parts 24, which also clearly shows that the heating parts 26 are heated by itself and not by the heat transferred from the power-supplied parts 24.

[0081] The present invention looks similar to aforementioned Patent Document 3 in view that the magnetic cores are used for applying the high-frequency magnetic flux through the side walls, but is totally different from it in view of the heating mechanism. Thus, according to Patent Document 3, only the side portions of the oven dish are magnetically interlinked with magnetic flux to be induction-heated by induction current running there-through. Contrary to this, according to the present invention, the overall of the heater 20 rather than only the power-supplied parts 24 of the heater 20 is induction-heated by induction current running throughout the looped heat-

er 20, which is caused by the high-frequency magnetic flux passing by (not penetrating through) the power-supplied parts 24 of the heater 20.

[0082] The temperature of the power-supplied part 24 increases moderately but eventually more than that of the heating part 26. This is partially because the power-supplied part 24 is heated by eddy current generated by magnetic flux running through the power-supplied part 24. This is also because a portion of the heating part 26 connected with the power-supplied part 24 is received in the groove 36 of the heat-insulating member 34 as shown in Fig. 10 so that the portion of the heating part 26 radiates thermal energy less than the other portions (at measurement points C, D), thereby raising the temperature thereof. Heat from the raised portion of the heating part 26 is transferred to the power-supplied part 24 which also radiates less thermal energy, which may make the temperature of the power-supplied part 24 higher. In other words, it is useful to provide the cooling part 25 as shown in Fig. 6B in order to lower the temperature of the power-supplied part 24. It may be needless to mention that while the temperature of the heating part 26 in the experiment of Fig. 11 is relatively low for grill-cooking, the temperature of the heating chamber 10 can be raised by providing the upper wall 12a and the front wall thereof and by supplying with greater power, which is suitable for grill-cooking.

[0083] The heating chamber 10 of the heating cooker 1 of Figs. 1 and 2 may include the side walls 14a, 14b made of metal such as iron plate, which may also be induction-heated by the magnetic flux generated by the coils 30a, 30b, as well as the magnetic members 32. Yet, the induction-heated side walls may efficiently raise the temperature of air within the heating chamber 10.

[0084] As explained above, the heating cooker 1 according to the present invention includes the induction-heating means on the side walls 14a, 14b of the heating chamber 10. Also, the heating cooker 1 includes the electrically looped heaters 20a, 20b which are detachably arranged within the heating chamber 10 and overall heated by induction current generated by high-frequency magnetic flux from the side walls 14a, 14b. This allows the heating chamber 10 more easily cleaned and the fat-receiving dish 38 of metal positioned beneath and spaced enough from the lower heater 20b.

[0085] It is not always necessary to provide two of upper and lower heaters 20a, 20b within the heating chamber 10, and only one of them may be arranged therein. When only one heater is provided, a single induction-heating means may be positioned adjacent either one of the upper and lower heaters 20a, 20b with the coil 30 wound in a planar shape as the present embodiment. This is applied to any one of following embodiments as well.

[0086] Embodiment 2. Fig. 12 is a cross sectional view of the heating cooker 1 according to the second embodiment of the present invention, and Fig. 13 is a perspective view schematically illustrating an overall of main

components of the heating cooker of Fig. 12. The induction-heating cooker 1 of the second embodiment is similar to one of the first embodiment except that only one coil is provided on the side wall 14 for supplying the high-frequency magnetic flux with the heater 20 formed in an electrical loop. Therefore, the duplicated description in detail for the common features will be eliminated. Similar components are denoted with similar reference numerals throughout the description.

[0087] As is clear upon comparing Figs. 12 and 13 of the heating cooker 1 according to the second embodiment with Figs. 1 and 2 thereof according to the first embodiment, the heating chamber 1 of the heating cooker 1 according to the second embodiment includes only one induction--heating means. This works well as clearly understood from the heating principle of the heating cooker 1 of the present invention that the heater magnetically interlinks with the high-frequency magnetic flux generated by electromagnetic induction, so that induction current runs through the heater formed in an electrical loop. Therefore, the second embodiment will be described as including one induction-heating means having one set of a coil and other components, while possibly having two sets as the first embodiment, or having three or more sets thereof. Also, what is described for the first embodiment may naturally be applicable for the heating cooker 1 according to the second embodiment.

[0088] In Fig. 12, the heating chamber 10 includes the left side wall 14b having grooves 39 for supporting the heaters 20a, 20b but no coil 30 provided thereon. The side wall 14b may be formed of metal material such as iron, in which at least one of the side wall 14b and heaters 20a, 20b should be coated with insulating material for electrical insulation between both of the heaters 20a, 20b. In general, the inner walls of the heating chamber 10 and the heaters 20a, 20b are coated with material for antifouling, protecting and/or far-infrared effects, therefore, such a coating may be adapted also for electrical insulation effect.

[0089] Next, an experimental result will be described herein. Fig. 14 is a graph showing the measured temperature of the heater 20 of the heating chamber 10 shown in Fig. 13. The driving condition of the induction-heating cooker 1 of the second embodiment is similar to one of the first embodiment except that a single induction-heating means is used. Thus the input power was 500W. As clearly understood from the graph of Fig. 14, the power-supplied parts 24 had temperature greater than the heating parts 26. Since the upper and lower heating parts 20a, 20b had the increased temperature different from one another in this experimental result, each of measurement was individually plotted in Fig. 14. The temperature of the upper and lower heaters 20a, 20b is different from each other, which is understood because each of them has different position or relationship against the induction-heating means and the lower heater is supplied with greater power. The heating parts 26 had the temperature saturated after about six minutes passed, but

the power-supplied parts 24 have the temperature kept further increasing thereafter. This is understood because the temperature of the heating parts 26 is increased by its own heat rather than by heat transferred from the power-supplied parts 24.

[0090] Upon comparison with Figs. 11 and 14 for the first and second embodiments of the heating cooker 1, it is clear that the power-supplied parts 24 have increased temperature greater than the heating parts 26, of which reason is understood as follows. Thus, while the temperature of the heating parts 26 depends upon the input power, the amount of heat generated by the heating parts 26 with input power of 500W according to the second embodiments in Fig. 14 is about half of that by the heating parts 26 with the input power of 1kW according to the first embodiment in Figs. 11, which reduces the temperature of the heating parts 26 of Fig. 14. In the meanwhile, since one of the induction-heating means is input with power of 500W both in the first and second embodiments, the amount of heat generated by eddy current in the power-supplied parts 24 of Fig. 14 is almost equivalent to that of Fig. 11. Thus, although the input power to the induction-heating means of Fig. 14 is reduced half, the power-supplied parts 24 of Fig. 14 have increased temperature substantially the same as ones of Fig. 11. Thus, when the heating cooker is designed to have a single induction-heating means having the coil 30 and other components, more amount of heat is generated in the power-supplied parts 24, therefore, it is useful to form the magnetic member in the C-shape as described in the first embodiment so as to increase magnetic flux passing by (not penetrating through) the heater 20 and reduce penetrating magnetic flux magnetically interlinked with the heater 20. This can suppress increased temperature of the power-supplied parts 24 and increase the temperature of heating parts 26 even when the heater 20 has one power-supplied part 24. When the heater 20 is provided with one power-supplied part 24, that is, when one induction-heating means is required, the manufacturing cost is advantageously reduced. Also, it brings another advantage that the degree of freedom for designing the structure of the heating cooker 1 can be expanded by arranging the induction-heating means only on the front wall 16 or the rear wall 18 as shown in Fig. 15, instead the side wall 14. Fig. 15 is a cross sectional view of the heating cooker 1 including the induction-heating means arranged on the rear wall 18. The magnetic member has the C-shaped cross section so as to suppress increased temperature of the power-supplied parts 24. Also, the front wall 16 of the housing (the heating chamber 10) may be structured to be opened and closed, and be partially composed of a front door 17 made of glass through which the inside thereof can be observed during cooking. The heating principle of the induction-heating means arranged on the rear wall 18 is similar to that on the side wall 14 as described in the above embodiments.

[0091] Despite the single induction-heating means, the heater 20 having two of the low-resistive parts 22 in both

ends thereof is used in this experiment, as illustrated in Figs. 6A, 6B, and 10. The heater 20 allows a user to easily install it within the heating chamber 10 without paying attention to the direction thereof, which eliminates or alleviates user's complicated installation and prevents malfunctioning due to wrong direction installation (erroneous installation in direction) of the heater 20.

[0092] Fig. 16 is a chart showing increased temperature of the heaters 20 which include one or two of the power-supplied parts 24 for comparison. The horizontal axis of Fig. 16 indicates length of the magnetic member 32, and the increased temperature of the magnetic member 32 having 60mm-long single power-supplied part 24 is obtained through the experiment of Fig. 14, and the increased temperature of the magnetic member 32 having 60mm-long two power-supplied parts 24 are detected through the experiment of Fig. 11. Thus, the structure of the heating chamber 10 and the driving conditions of the induction-heating means are the same as those of the first and second embodiments. The vertical axis of Fig. 16 indicates relative increased temperature when the increased temperature of the single 60mm-long power-supplied part 24 measured at 30 seconds after initiation of power supply. The input power to the induction-heating means is set as 500W with the single power-supplied part 24 and as 1kW with two power-supplied parts 24. Thus, either one the power-supplied parts 24 is supplied with power of 500W. The reason why the increased temperature is measured at 30 seconds after initiation of power supply is to compare the increased temperature of the power-supplied parts 24 when they are not too hot for reducing influence of the heat radiation. While two of the heaters 20a, 20b are provided, in case where each of them has two power-supplied parts 24, the increased temperature is plotted in Fig. 16 by averaging the temperature of the power-supplied parts 24.

[0093] As can be seen from Fig. 16, the increased temperature of the power-supplied part 24 with two of the power-supplied parts 24 is less than that with one of the power-supplied part 24. Also, as the magnetic member 32 is longer, the increased temperature of the power-supplied part 24 is lower, but is not proportional to the length thereof and almost saturated at the length of 120mm or greater in this experiment of Fig. 16. Furthermore, the increased temperature of the power-supplied part 24 with two of the power-supplied parts 24 each having the length of 60mm is almost equal to that with one the power-supplied part 24 having the length of 120mm. However, if the heating cooker 1 is supplied with power of 1kW, each of two power-supplied parts 24 is heated with power of 500W as a solid line in Fig. 16 while single power-supplied part 24 is heated with power of 1kW as a dashed line, of which temperature is almost double of the former one.

[0094] Therefore, even when the magnetic member 32 has entire length equal as each other, one having two power-supplied parts 24 is more advantageous than one having single power-supplied part 24. This is understood

because the power-supplied part 24 is a power source and it is effective to provide more power sources in number for generating induction current through the heater. As discussed above, the magnetic member 32 having the C-shaped cross section advantageously suppresses the increased temperature of the power-supplied part 24 than that having U-shaped cross section. On the other hand, when the heater 20 is provided with the single power-supplied part 24 only on either one of the side walls 14, the rear wall 18 and the front wall 16 of the heating chamber 10, the heating chamber 10 can be structured simply, designed with greater degree of freedom, and manufactured at a more reasonable cost.

[0095] Fig. 17 is a perspective view schematically illustrating an overall of the heating cooker, including the heater 20 provided with two power-supplied parts 24 and the induction-heating means arranged on the rear wall 18 of the heating chamber 10. Fig. 17 also illustrates just main components of the heating cooker like Fig. 2 and eliminates the heat-insulating members 34 for clarity. Thus, although not shown, the heating chamber 10 of Fig. 17 is also composed of the side wall 14 and others required for defining the heating chamber 10 as shown in Fig. 1. Each of the heaters 20a, 20b is provided with two of the power-supplied parts 24 close to the rear wall 18 of the heating chamber 10. A single coil 30 is arranged outside the heating chamber 10 adjacent the rear wall 18 thereof, thus four of the U-shaped magnetic members 32 are provided in total along the coil 30. Each of the magnetic members 32 may be C-shaped as well.

[0096] When supplied with high-frequency current, the coil 30 generates high-frequency magnetic flux with which heaters 20a, 20b magnetically interlink, thereby inducing current throughout the heaters by electromagnetic induction. Since each of the heaters 20a, 20b has two power-supplied parts 24, even with single coil provided along the rear wall 18, increased temperature of the power-supplied parts 24 can be suppressed, while keeping high temperature of the heating part 26.

[0097] Embodiment 3. Fig. 18 is a cross sectional view of the heating cooker 1 according to the third embodiment of the present invention, and Fig. 19 is a perspective view illustrating an overall of main components of the heating cooker of Fig. 18. The induction-heating cooker 1 of the third embodiment is similar to one of the first embodiment except that the coil 30 is formed by spirally winding a conductive wire around the magnetic member 32 so as to supply the high-frequency magnetic flux with the heater 20 formed in an electrical loop. Therefore, the duplicated description in detail for the common features will be eliminated. Similar components are denoted with similar reference numerals throughout the description.

[0098] As illustrated in Figs. 18 and 19, each of the coils 30a-30d is formed by a spirally winding a conductive wire such as a litz wire around the base portion 40 of the magnetic member 32 having the U-shaped configuration. Although only the coils 30a, 30c are shown in Fig. 19, the other coils 30b, 30d are just invisible behind the heat-

insulating members 34 but actually existed. Each of the coils 30a-30d may be supplied with high-frequency current by an individual power circuitry (not shown). A pair of the coils 30a, 30c and a pair of the coils 30b, 30d may be electrically connected in series or parallel to be supplied with high-frequency current by two of the power circuitries, respectively. Alternatively, a pair of the coils 30a, 30b and a pair of the coils 30c, 30d may be electrically connected in series or parallel to be supplied with high-frequency current by two of the power circuitries, respectively. Furthermore, all of the coils 30a-30d may be electrically connected in series or parallel to be supplied with high-frequency current by the single power circuitry.

[0099] Preferably each of the coils 30a-30d are connected to induced current running throughout the heaters 20a, 20b in directions as shown in Fig. 4 of the first embodiment. By connecting each of the coils 30a-30d in series or in parallel, or by connecting the pair of the coils 30a, 30b and the pair of the coils 30c, 30d to be supplied with high-frequency current, the upper and lower heaters 20a, 20b may be separately heated, and therefore, each of the heaters 20a, 20b may be thermally controlled in an individual manner and/or either one of them may be driven for a desired cookery purpose.

[0100] Figs. 20 and 21 are enlarged cross sectional views of the induction-heating means with the coil 30 generating magnetic flux according to the third embodiment. The magnetic members 32 of Figs. 20 and 21 have the U-shaped and C-shaped cross sections, respectively. As can be seen from those drawings, the magnetic flux (ϕ_1 , ϕ_2) are generated by the coils 30 similarly as described in the first and second embodiments. Thus, the coils 30 according to the third embodiment may be replaced with ones as explained in the first and second embodiments, and also the technique in the first and second embodiments can equally be applied to the third embodiment. Also, as illustrated in Fig. 22, the coil 30 may be wound around another portion (e.g., the side portion 42 extending from the base portion 40) of the magnetic member 32 different from ones of Figs. 20 and 21.

[0101] Embodiment 4. Fig. 23 is a cross sectional view of the heating cooker 1 according to the fourth embodiment of the present invention, and Fig. 24 is a perspective view schematically illustrating an overall of main components of the heating cooker of Fig. 23. The induction-heating cooker 1 of the fourth embodiment is similar to one of the first embodiment except that the coil 30 is formed by spirally winding a conductive wire around two of adjacent magnetic members 32 so as to supply the high-frequency magnetic flux with the heater 20 formed in an electrical loop. Therefore, the duplicated description in detail for the common features will be eliminated. Similar components are denoted with similar reference numerals throughout the description.

[0102] In Figs. 23 and 24, four of the magnetic members 32 having U-shaped configuration are provided on the side walls 14 of the heating chamber 10 as the first

embodiment, and each of the coils 30a, 30b is formed by a spirally winding a conductive wire such as a litz wire around the side portions 42 of two neighboring magnetic members 32 provided on the side wall of the heating chamber 10. Thus, the conductive wire of the fourth embodiment is spirally wound around the side portions 42 of the magnetic members 32 positioned on and along one of the side walls 14 of the heating chamber 10. When high-frequency current is supplied with the coils 30a, 30b so structured, the heaters 20a, 20b magnetically interlinks with magnetic flux generated as described in the above embodiments, which are heated by induction current running therethrough. While Figs. 23 and 24 illustrate the magnetic members 32 formed in the U-shaped configuration, the magnetic members 32 may have another cross sectional configuration such as the Cshaped configuration.

[0103] Fig. 25 is a cross sectional view of the heating cooker 1 having a magnetic member 32 formed in a E-shaped configuration which seems like two of neighboring U-shaped magnetic members combined together. Thus, the magnetic member 32 of Fig. 25 has a base portion 40, a pair of side portions 42a, 42b extending perpendicularly to the base portion 40 from ends thereof, and a middle portion 42c extending from the middle thereof. Also, the magnetic member 32 shown in Fig. 25 has two of grooves (openings) 36a, 36b between the middle portion 42c and each of the side portions 42a, 42b. The heaters 20a, 20b are inserted into the grooves 36a, 36b, respectively.

[0104] Since the E-shaped magnetic member 32 of the fourth embodiment may be regarded as combination of two of the U-shaped magnetic members, the heating cooker 1 of Fig. 25 is substantially the same as that of Figs. 1 and 2. Thus, the E-shaped magnetic member 32 is treated as combined magnetic member composed of two U-shaped magnetic members. Therefore, the E-shaped magnetic member 32 may have upper and lower portions each of which is C-shaped, and other features in its cross section as explained in the above embodiments. Also, the planar coil of the first embodiment may be used together with the E-shaped magnetic member 32 of Fig 25.

[0105] Embodiment 5. Figs. 26A and 26B are cross sectional views of the heating cooker 1 according to the fifth embodiment of the present invention. Fig. 27 is a perspective view and Fig. 28 is a cross sectional view showing the induction-heating means of the heating cooker according to the fifth embodiment. The induction-heating cooker 1 of the fifth embodiment is similar to one of the second embodiment except that it has another magnetic member 32 which can be assembled to surround the heater 20 entirely in its cross section. Therefore, the duplicated description in detail for the common features will be eliminated. Similar components are denoted with similar reference numerals throughout the description.

[0106] As discussed in the above embodiments 1-4,

the heating cooker 1 includes the magnetic member 32 formed in the U-shaped or C-shaped cross section, and the heaters 20 magnetically interlinked with magnetic flux including one (ϕ_1) that does not pass through the heater 20 and another (ϕ_2) that penetrate the heater 20. Also, the magnetic flux (ϕ_1) passing by (not penetrating through) the heater is more effective to generate Joule heat in the heating part of the heater 20 owing to reduction of heat by the eddy current within the power-supplied part 24 thereof. As will be described herein, the heating cooker 1 according to the fifth embodiment can maximize magnetic flux which does not penetrate through the heater 20 and causes optimal magnetic interlinkage therewith.

[0107] Figs. 26A and 26B illustrate the heating cooker 1 including the induction-heating means provided on the rear wall 18 of the heating chamber 10 as the second embodiment shown in Fig. 15, yet the induction-heating means may be arranged on either one or both of the side walls 14 as described in other embodiments. Also, while the coil 30 is illustrated as being formed by spirally winding a conductive wire such as a litz wire, it may be formed by winding the conductive wire in a planer configuration as mentioned in the first and second embodiments. The heating cooker 1 of Fig. 26 includes the coil 30 and other components composing the induction-heating means, which are structured differently from the heating cooker 1 shown in Fig. 15, but similarly to those of any embodiments in view of the other components.

[0108] The coils 30a, 30b are made by spirally winding a conducting wire around a portion of the magnetic member 32 which is O-shaped and has no opening 36 in the cross section. The O-shaped magnetic member 32 is provided with the heat-insulating member 34 to prevent the magnetic member 32 and the coils 30a, 30b from being heated by the heaters 20a, 20b. Also, another heat-insulating member 45 is provided around the O-shaped magnetic member 32 and along the inside wall of the heating chamber 10 in order to prevent the magnetic member 32 from being exposed in hot air within the heating chamber 10. The heat-insulating member 34 defines the inner groove 36 for receiving the power-supplied part 24 of the heater 20. Thus, the portions of the O-shaped magnetic member 32 and the heat-insulating member 45 compose a movable component 52 which can be separated and slid in parallel.

[0109] In other words, the induction-heating means of the heating cooker 1 according to the fifth embodiment includes a stationary component 50 fixed with the heating chamber 10 and a movable component 52 designed as being slidable over the stationary component 50. The stationary component 50 includes the outer heat-insulating member 45, the coil 30, the U-shaped magnetic member 32, and the heat-insulating member 34 with the groove for receiving the power-supplied part 24 of the heater 20. Meanwhile, the movable component 52 includes the outer heat-insulating member 45, the magnetic member 32 for defining a closed magnetic circuit (ϕ_1)

in cooperation with the U-shaped magnetic member 32 of the stationary component 50, and the heat-insulating member 34. Thus, when the movable component 52 is slid in a closed position, both of the U-shaped magnetic member 32 of the stationary component 50 and the movable component 52 in cooperation define a continuous closed magnetic circuit (ϕ_1).

[0110] Fig. 26A illustrates the movable component 52 in the closed position ready for supplying induction current through the heaters 20a, 20b for heating. Fig. 26B illustrates the movable component 52 in the opened position allowing the heaters 20a, 20b detached from the heating chamber 10. The movable component 52 may be operated manually or automatically by means of mechanical means.

[0111] Fig. 27 is a perspective view of the induction-heating means showing a concrete structure of the stationary component 50 and the movable component 52. While Fig. 27 illustrates the induction-heating means provided for the lower heater 20b, it may have a similar structure thereof for the upper heater 20a. Illustration is made especially focusing on the power-supplied part 24 of the heater 20b, which is formed in an electrically closed loop as described in the above embodiments. Fig. 27 illustrates the movable component 52 in the opened position over the stationary component 50. As illustrated, the magnetic member 32 of the stationary component 50 is surrounded by the heat-insulating member 34 and is exposed in a portion opposing to a bottom portion (not shown) of the movable component 52. The exposed portion of the magnetic member 32 may be coated with a thin protection film. The groove 36 provided inside the heat-insulating member 34 is a box-shaped, and when the movable component 52 is closed, the heating chamber 10 is designed to be thoroughly closed except a heater-access port 54. When the movable component 52 is closed, the heater access port 54 is structured to have a cross section conforming with the cross section of the heater 20. Also, when the power-supplied part 24 is inserted within the groove 36 and the movable component 52 is closed, the heating chamber 10 is formed to be sealed without interchanging air in the heating chamber 10 with air in the groove 36. However, in case where there is a gap formed between the heater-access port 54 and the heater 20 and hot air within the heating chamber 10 flows into the groove 36, blowing means for blowing outside air into the heating chamber 10 may be provided so as to cool inside the groove 36 or to increase pressure in the groove 36 higher than that in the heating chamber 10, thereby to prevent hot air from being introduced into the groove 36. With such structure, the detachable heater 20 and the magnetic member 32 having the O-shaped cross section can be realized.

[0112] Fig. 28 is an enlarged view of the magnetic flux generated by the induction-heating means of the heating cooker 1 of Fig. 26A, showing the lower heater 20b, especially the magnetic member 32 having the O-shaped cross section. As shown in Fig. 28, most of the magnetic

flux ($\phi 1$) generated by the high-frequency current through the coil 30b runs through the O-shaped magnetic member 32. Therefore, most of the magnetic flux ($\phi 1$) does not penetrate through the heater 20b, with which the heater 20b magnetically interlinks. As the result, the heater 20 is sufficiently heated by the induction current rather than the eddy current which is generated by the magnetic flux ($\phi 1$).

[0113] While the fifth embodiment has been described for the detachable heater 20 with the magnetic member 32 having the O-shaped cross section, it is still advantageous even if the heater is fixed (not detachable) with the inside of the heating chamber 10. Thus, the power-supplied part 24 of the heater 20 formed in an electrical closed loop may be arranged outside the heating chamber 10 and may be heated by induction current caused by the induction heating means having the O-shaped magnetic member 32. In this case, as seen from the inside of the heating chamber 10, the heater 20 may have similar structure of a commonly used sheath heater for a conventional IH cooking heater. However, the sheath heater is composed of a ceramics sheath surrounding a heating core wire, which is inserted in a pipe of metal such as stainless steel, and therefore its structure is complicated. Also, since the conventional sheath heater has the heating core wire within the metal pipe, there is a restriction in curvature when bending it to have a desired shape. As more portions of the sheath heater are bent for the desired shape, it is more expensive to produce it. Furthermore, since the conventional sheath heater has ceramic sheath filled within the metal pipe, it has substantial heat capacity and requires much time to be well heated. On the other hand, since the heater 20 of the present invention can be made from a stainless steel pipe for example, it can be bent or curved more flexibly and more reasonably in comparison with the sheath heater. Also, when the heater 20 is made of metal pipe having less heat capacity, it can be heated more quickly than the sheath heater. The heater 20 with the U-shaped or C-shape magnetic member 32 of the present invention has several advantages over the conventional sheath heater as described in the above embodiments. In addition, even if the heater 20 is designed to be fixed and not detachable within the heating chamber 10, the heater 20 of the present invention still has another merit that Joule heat generated by eddy current in the power-supplied part 24 can be minimized by means of the O-shaped magnetic member 32 as described in the fifth embodiment. It should be noted that although the present embodiment describes the coil 30 formed by spirally winding a conductive wire around a portion of the magnetic member 32, the coil may be formed as similar ones illustrated in the first or fourth embodiment.

[0114] Embodiment 6. Fig. 29 is a cross sectional view of the heating cooker 1 according to the sixth embodiment of the present invention, and Fig. 30 is a perspective view schematically illustrating an overall of main components of the heating cooker of Fig. 29. The heating cooker 1 of

the sixth embodiment is similar to one of the first embodiment except that the heaters 20a, 20b are provided along the side walls 14 so that the food within the heating chamber can be heated from the side surfaces. Therefore, the duplicated description in detail for the common features will be eliminated. Similar components are denoted with similar reference numerals throughout the description.

[0115] In the above first through fifth embodiments, the heating cooker 1 includes a heater 20 provided within the heating chamber 10 substantially along a horizontal direction, the heating cooker 1 according to the sixth embodiment includes another type of the heater 20. However, since the heating principle of the heater of the present embodiment is the same as aforementioned one, any one of the induction-heating means described in the above embodiments can be used in this embodiment as well.

[0116] Fig. 31 is a perspective view illustrating main components having a heater 20 of the heating cooker 1 of modification according to the sixth embodiment. Each of the heaters 20a-20d shown in Fig. 31 has the power-supplied part 24 made from a solid metal bar having low resistance (e.g., a solid copper bar), and a heating part 28 made from a thin metal plate having high resistance and high fusing point (e.g., a thin tungsten plate). The heating part 28 is received within an airtight case 56 of quarts or translucent ceramics which is hermetically sealed and filled up with inert gas such as argon. Like the above embodiments, when the coils 30a, 30b are supplied with high-frequency current, the induction current runs through each of the heaters 20a-20d, so that the heating parts 28 are heated. Since the heating part 28 is made of metal having high fusing point and the airtight case 56 is filled up with inert gas, the heating part 28 can be heated up to high temperature in a range between 1000-2000 degrees C. This allows substantial amount of near-infrared and far-infrared radiation from the heating part 28, similar to an electrical light bulb such as a halogen lamp which generates substantial amount of light emission, heat, and infrared radiation. This radiation heating with infrared light makes the food grill-cooked.

[0117] Fig. 32 is a perspective view illustrating main components including a heater 20 of the heating cooker 1 of further modification according to the sixth embodiment. The upper heaters 20a, 20b are the same as those shown in Fig. 31. The lower heater 58 is made from a metal plate (e.g., a stainless steel plate) having thickness of approximately 2mm which has several cutouts 59 as illustrated in Fig. 32. Each of the cutouts 59 may have a width enough for securing electrical insulation therein.

[0118] The heating cooker 1 as structured in Fig. 32 is suitable for grill-cooking a hamburger steak, for example. Thus, after the hamburger steak is set on the lower heater 58, each of the coils 30a, 30b is supplied with the high-frequency current so that it is heated by the upper heaters 20a, 20b and the lower heater 58. The lower heater 58 is heated up to approximately 200 degrees C to burn the

hamburger steak like a frying pan. The fat coming from the food and falling down through the cutouts 59 is received onto a fat-receiving dish (not shown) arranged beneath the lower heater 58. Also, as explained above, each of the upper heaters 20a, 20b radiates infrared light for grill-cooking the hamburger steak.

[0119] As shown in Figs. 33 and 34, the lower heater 58 composing a high-resistive core member may be covered on its upper and lower surfaces with a cladding member 175 made of insulating material such as ceramics so as to keep the cutouts unexposed and form the lower heater 58 as a plate-like configuration. Fig. 33 is a perspective view of an overall of the plate-like lower heater 20 with the cutouts 59 unexposed, and Fig. 34 is a cross sectional view thereof. Thus, this lower heater 58 can be formed by covering (sandwiching or encompassing) the metal plate having the cutouts 59 with the cladding member 175 of insulation material such as ceramics. Although the cladding member 175 may be made of metal, another insulation material or coating is required for electrical insulation between the lower heater 58 and the cladding member 175.

[0120] Fig. 35 is a perspective view illustrating main components including a heater 20 of the heating cooker 1 of even further modification according to the sixth embodiment. As shown in Fig. 35, the heater 20 is housed within a box-shaped airtight container 70 having a lid member 72 and a container member 74. The box-shaped airtight container 70 performs as an oven or a kettle, and oven-cooking and oven-cooking of the food inside the box-shaped airtight container 70 can be achieved by heating the lid member 72 and the container member 74.

[0121] Fig. 36 is a development view of the lower heater 20 housed in the container member 74, which is assembled to form the lower heater by bending up at dashed lines. The upper heater 20 of the lid member 72 is also assembled in a similar manner. The heater 20 includes the low-resistive parts 22 and the high-resistive part 26, in which each of the low-resistive parts has the power-supplied part and the cooling part as discussed in the above embodiments. The high-resistive part 26 is formed by punching a metal plate (e.g., stainless steel or aluminum plate) in a shape like Fig. 36. Fig. 37 is a cross sectional view of the box-shaped airtight container 70. The lid member 72 includes a lid body 73 of insulation material such as ceramics and the high-resistive part 26, and the container member 74 also includes a container body 75 of insulation material and the high-resistive part 26 as well.

[0122] The lid body 73 and the container body 75 may be made of metal. But if this is the case, since it is necessary to insulate the high-resistive part 26 from the lid body 73 and the container body 75, a thermal and electrical insulation film such as ceramic sheet should be interposed between the high-resistive part 26 and the lid body 73 (and the container body 75). When the lid body 73 and the container body 75 are made of aluminum, for example, they may be anode-oxidized (alumite-treat-

ment) to form an alumina layer (an oxidized aluminum layer) on the surface thereof, thereby producing an insulating layer without preparing a separate insulating member at a reasonable cost. When the coils 30 of the heating cooker 1 shown in Fig. 35 are supplied with the high-frequency current, the heaters 20 provided within the lid body 73 and the container body 75 are heated by induction current therethrough, so that the food within the box-shaped airtight container 70 is heated and cooked. Even in case where the heating cooker 1 is used as an oven, since the heated air within the box-shaped airtight container 70 is 300 degrees C or less which is less than the melting point of aluminum, the lid body 73 and the container body 75 can be produced of aluminum at a reasonable cost.

[0123] Fig. 38 is a perspective view illustrating main components including a heater 20 of the heating cooker 1 of even further modification according to the sixth embodiment. As shown in Fig. 38, the upper heater 20 is similar to that of Fig. 2, and the lower heater 58 is similar to that of Fig. 32. Preferably, the upper heater 20 may have the high resistive part made from a pipe (a hollow bar) since it is generally spaced from the food for cooking. On the other hand, the lower heater 58 may preferably have the high resistive part made from a metal plate having substantial surface area for uniform cooking. The upper and lower heaters may be have different configuration (shape, size, position) from each other, and may be designed as being detachable, therefore, any type of them may be chosen and replaced with another one in accordance with the food to be cooked.

[0124] Fig. 39 is a cross sectional view illustrating a heating cooker 1 of even further modification according to the sixth embodiment. The induction-heating cooker 1 of Fig. 39 is similar to one of the third embodiment of Fig. 18 in structure and operation, except that the former has the coils 30a, 30b provided over the upper wall 12a and beneath the lower wall 12b rather than on the side walls 14a, 14b. In other words, although the induction heating means with the coils 30 are described as being arranged on the side walls in the above embodiments, the present invention can equally be adapted to the induction heating means provided over the upper wall 12a and beneath the lower wall 12b as illustrated in Fig. 39. Also needless to mention again, the induction heating means may be provided on the front and rear walls, and the side walls may include the front and rear walls as well.

[0125] As described above, according to the heating cooker 1 of the present invention, the heater is structured as being detachable, therefore, the easy-to-clean feature is fairly improved and various types of the heaters 20 may be used appropriate for cooking purposes, thereby realizing a multifunctional heating cooker.

Claims

1. A heating system, comprising:

- a box-shaped heating chamber;
 a heater provided inside said heating chamber,
 said heater being made of conductive material
 in an electrical loop;
 a coil provided outside said heating chamber;
 a power circuitry for supplying high-frequency
 current with said coil to generate high-frequency
 magnetic flux; and
 a magnetic member arranged so that said heater
 magnetically interlinks with the high-frequency
 magnetic flux generated by said coil.
2. The heating system according to claim 1, wherein
 said coil and said magnetic member are arranged
 along a wall composing said heating chamber, and
 wherein the high-frequency magnetic flux causes in-
 duction current running through said heater.
 3. The heating system according to claim 2, wherein
 said heating chamber is composed of front, rear, left-
 side, right-side, upper and lower walls, wherein said
 coil and said magnetic member are arranged along
 one of said walls.
 4. The heating system according to any one of claims
 1-3, wherein said coil is formed by winding a con-
 ductive wire in a planer configuration, and wherein
 said magnetic member surrounds a plurality of por-
 tions of the wound conductive wire through which
 the high-frequency current runs in the same direc-
 tion.
 5. The heating system according to any one of claims
 1-3, wherein said coil is formed by spirally winding
 a conductive wire around a part of said magnetic
 member.
 6. The heating system according to any one of claims
 1-5, wherein said magnetic member is arranged so
 that two of said heaters magnetically interlink with
 the high-frequency magnetic flux generated by said
 coil.
 7. The heating system according to any one of claims
 1-6, wherein said magnetic member has a U-shaped
 cross section, and wherein a part of said heater is
 inserted in an opening of the U-shaped cross section
 of said magnetic member.
 8. The heating system according to any one of claims
 1-6, wherein said magnetic member has a C-shaped
 cross section, and wherein a part of said heater is
 inserted in an opening of the C-shaped cross section
 of said magnetic member.
 9. The heating system according to any one of claims
 1-6, wherein said heater has a power-supplied part,
 and wherein said magnetic member surrounds the
- power-supplied part entirely.
10. The heating system according to any one of claims
 1-9, wherein said heater includes a low-resistive part
 and a high-resistive part, and wherein the low-resis-
 tive part magnetically interlinks with the high-fre-
 quency magnetic flux.
 11. The heating system according to claim 10, wherein
 the low-resistive part and the high-resistive part are
 made of solid metal and hollow metal, respectively.
 12. The heating system according to claim 10, wherein
 the high-resistive part is a metal plate provided with
 a plurality of cut-outs.
 13. The heating system according to any one of claims
 10-12, wherein the high-resistive part is provided
 with insulating material on its surface.
 14. The heating system according to claim 12 or 13,
 wherein said heater includes a plate-like member
 encompassing the high-resistive part.
 15. The heating system according to claim 12 or 13, fur-
 ther comprising a box-shaped container encom-
 passing the high-resistive part.
 16. The heating system according to claim 10 or 11,
 wherein the low-resistive part includes a cooling part
 exposed in atmosphere within said heating chamber.
 17. The heating system according to any one of claims
 1-16, wherein said heating chamber is made of met-
 al, and wherein at least either one of the inner walls
 of said heating chamber or said heater are coated
 with insulating material.
 18. The heating system according to any one of claims
 1-17, wherein said heater magnetically interlinks
 with the high-frequency magnetic flux generated by
 a plurality of said coils.
 19. The heating system according to any one of claims
 1-18, wherein said heater is detachably installed
 within said heating chamber.
 20. The heating system according to claim 19, wherein
 a plurality of said heaters is detachably installed with-
 in said heating chamber.
 21. The heating system according to claim 20, wherein
 various types of said heaters are detachably installed
 within said heating chamber.

Fig. 1

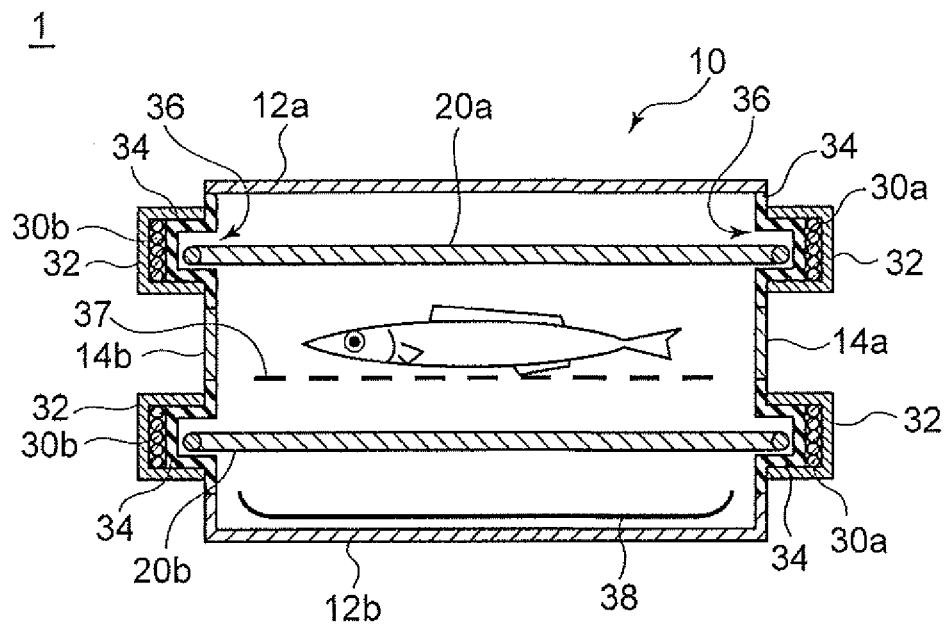


Fig. 2

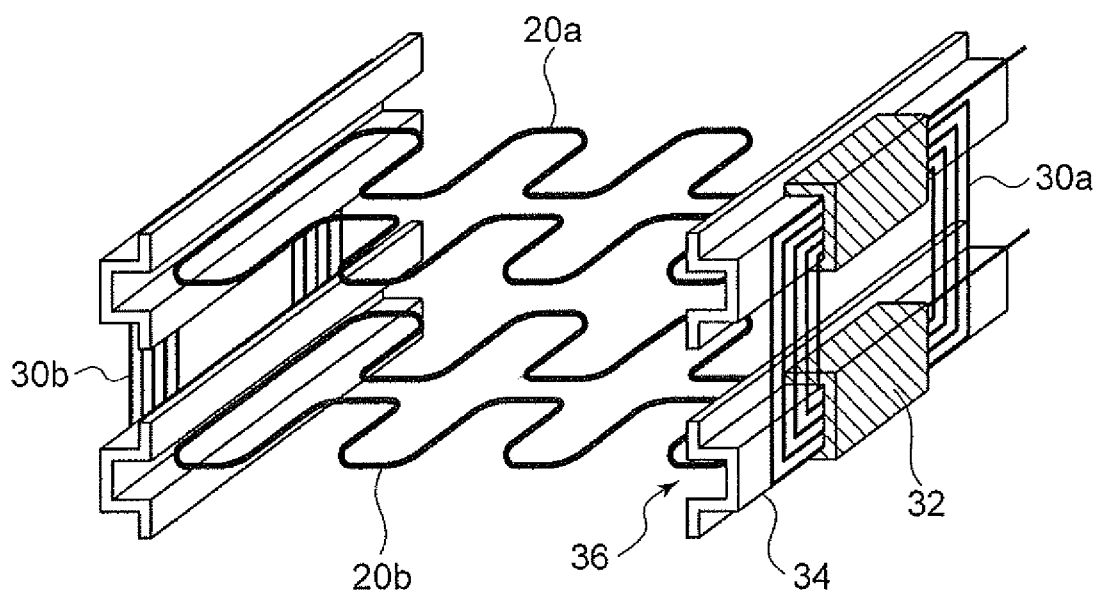


Fig.3

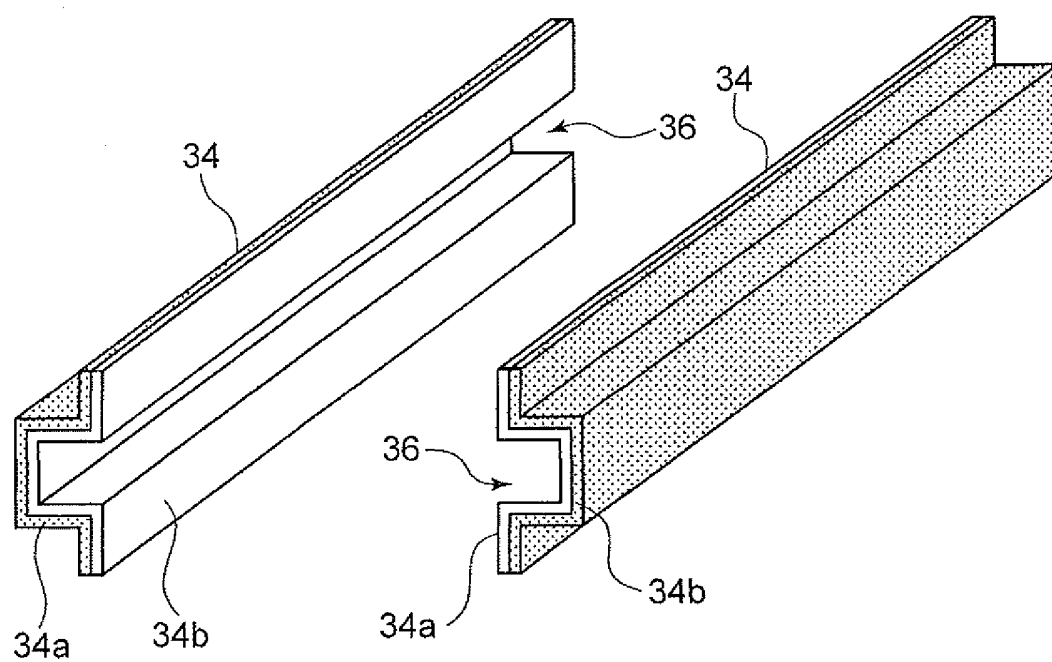


Fig.4

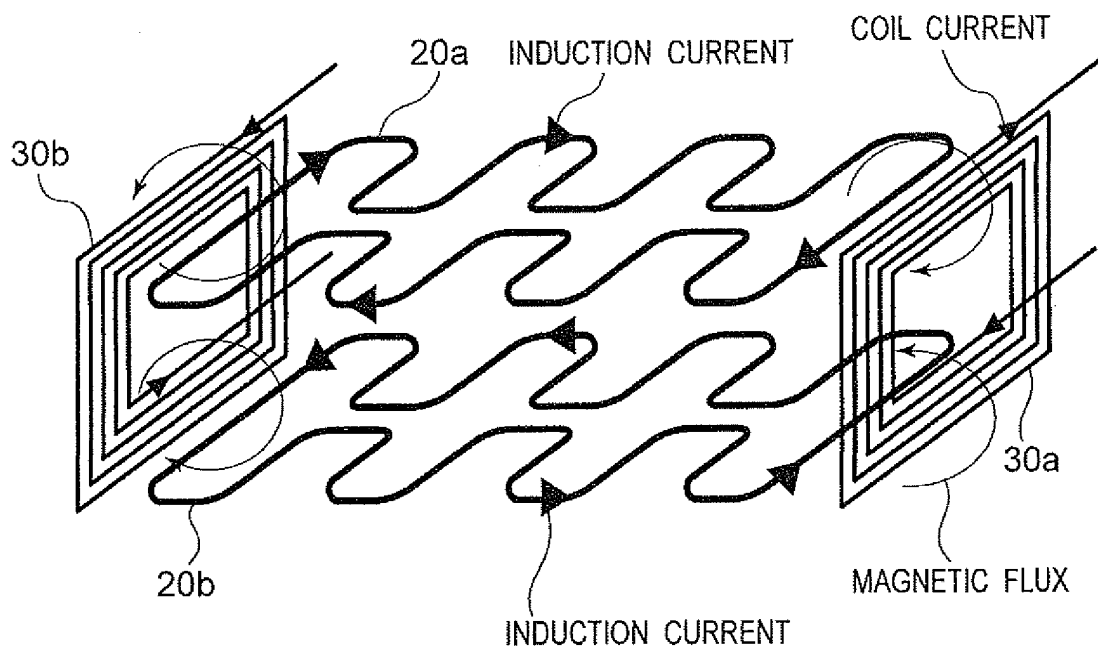


Fig.5

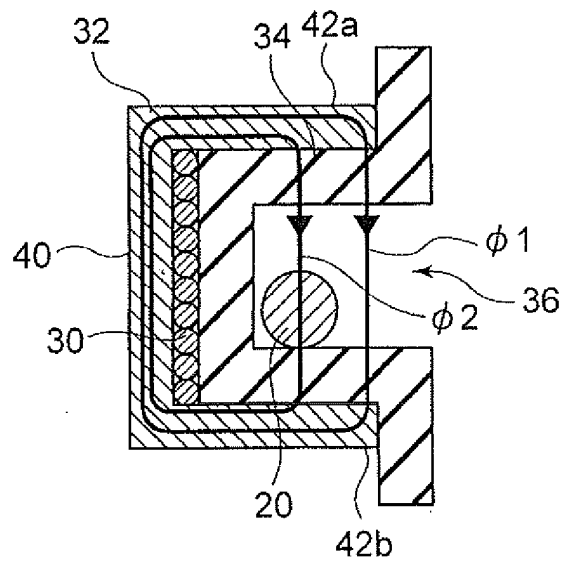


Fig. 6A

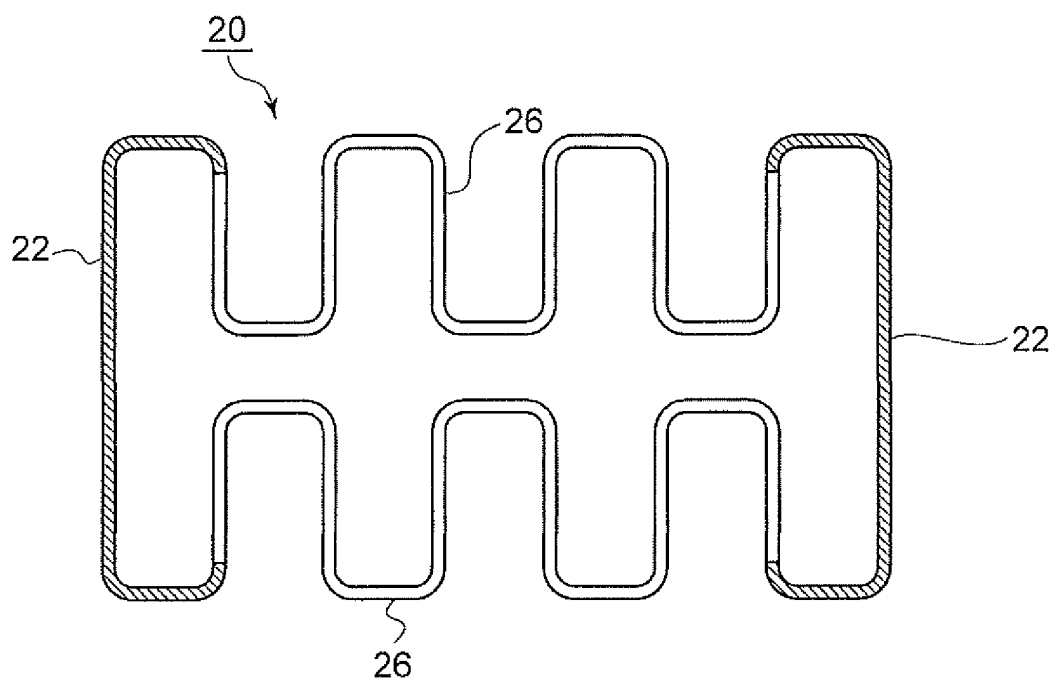


Fig. 6B

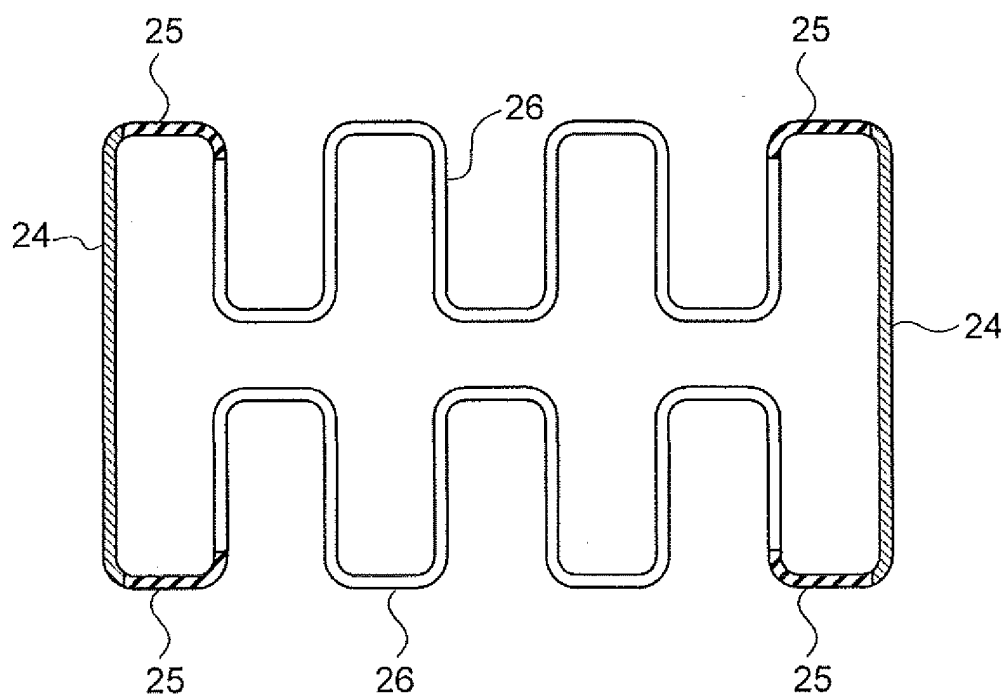


Fig.7

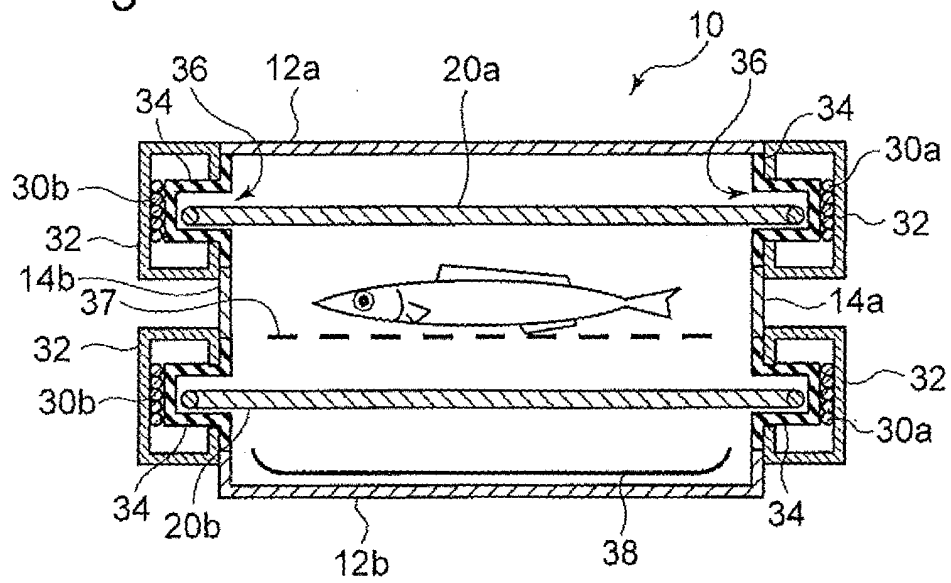


Fig. 8

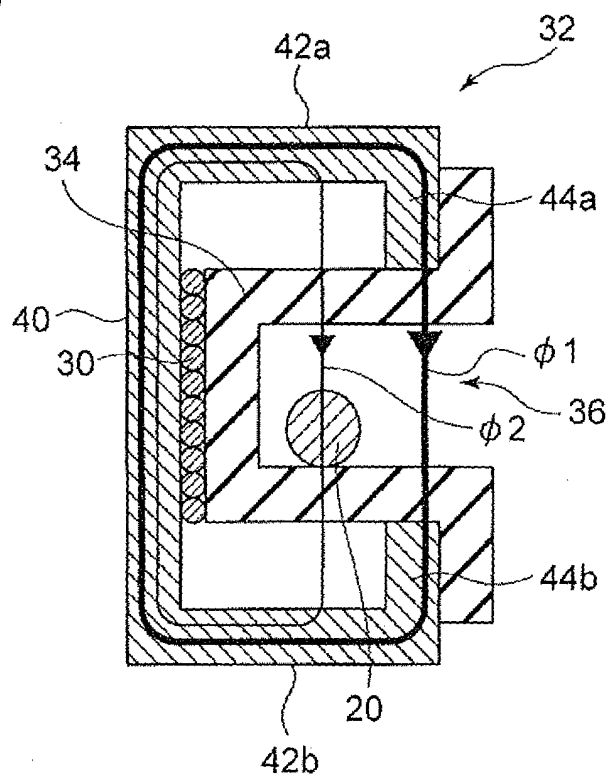


Fig.9

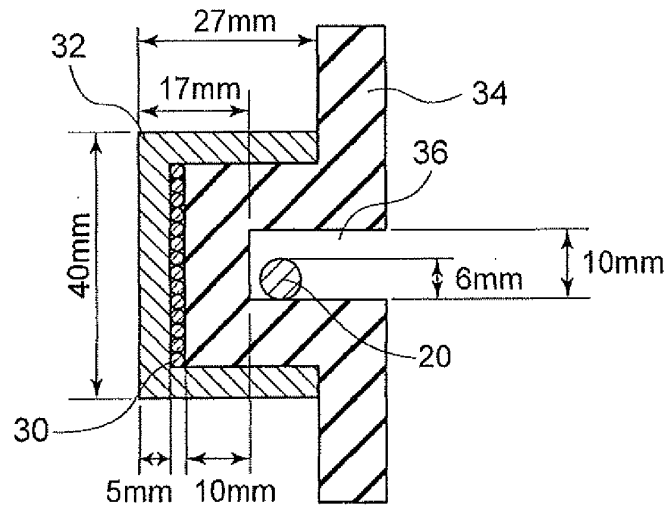


Fig. 10

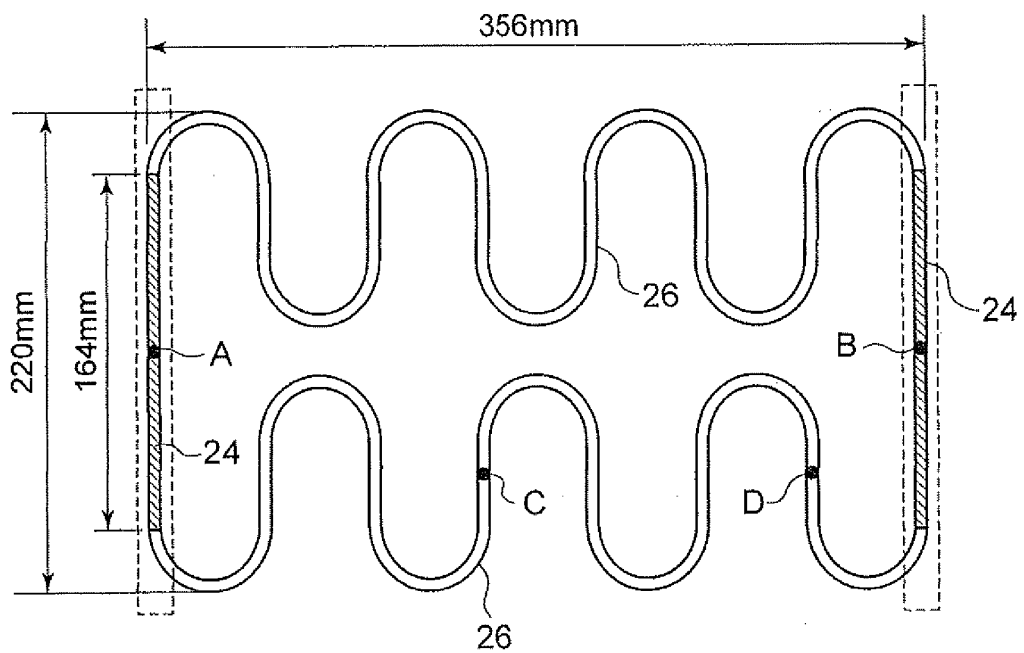


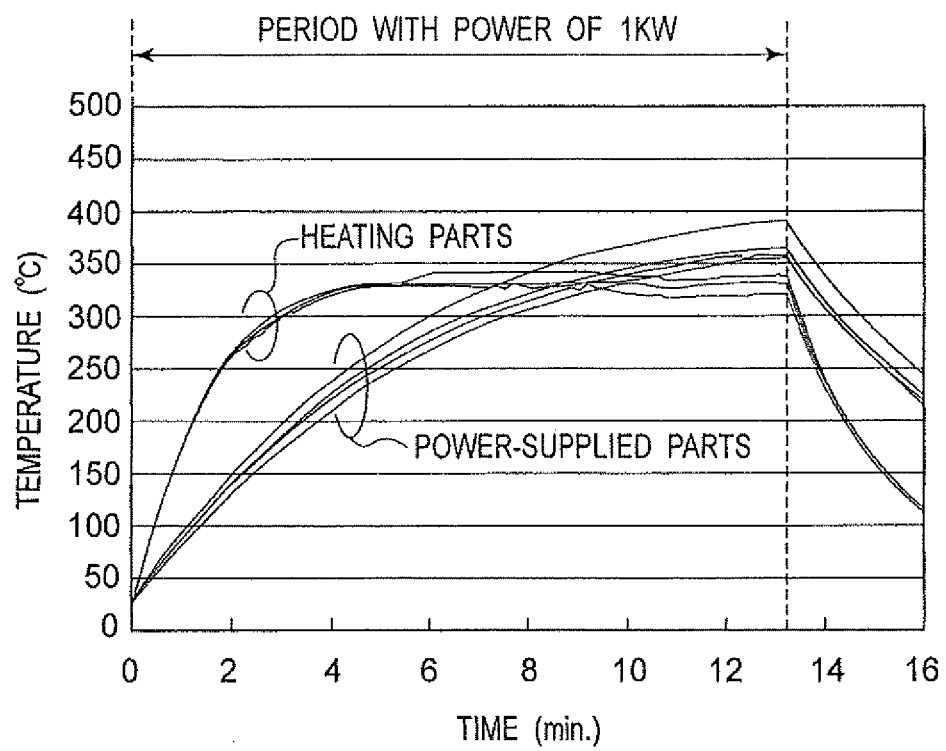
Fig. 11

Fig.12

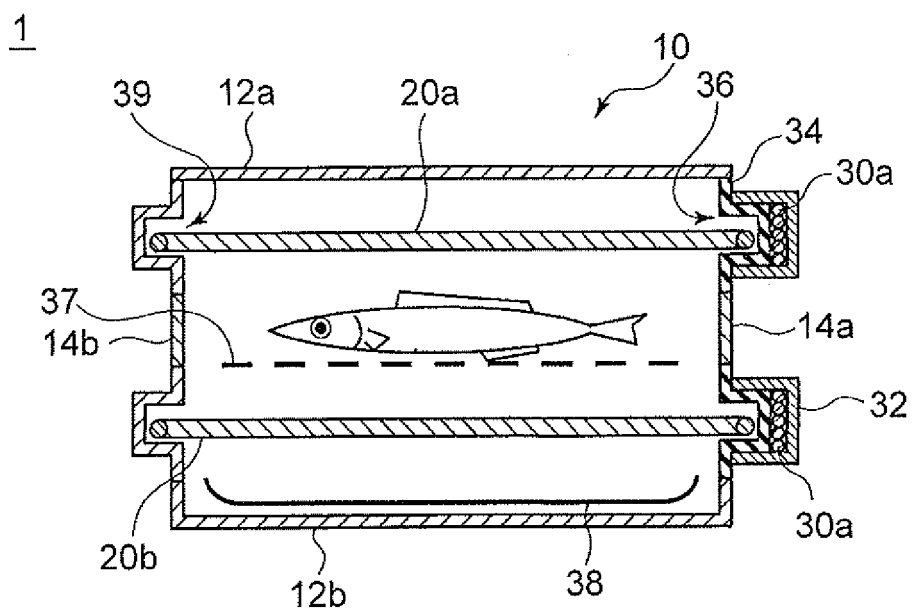


Fig.13

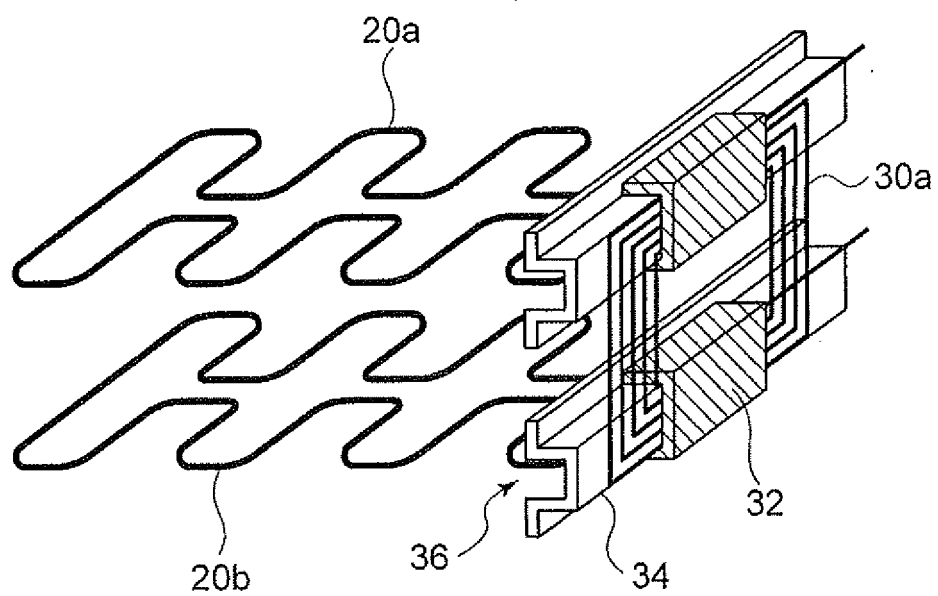


Fig.14

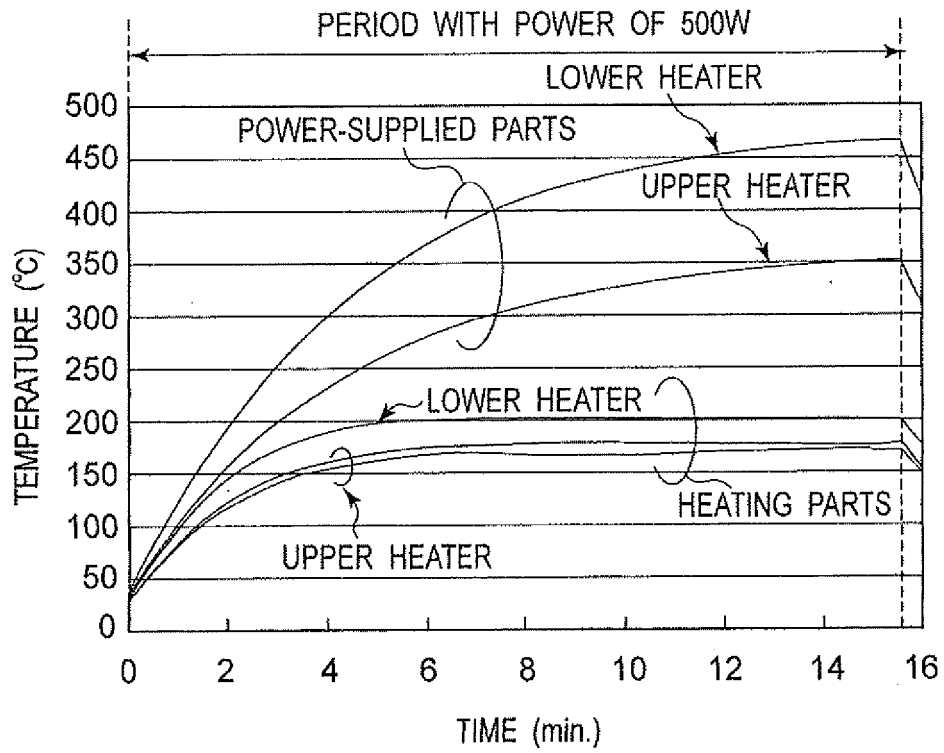


Fig.15

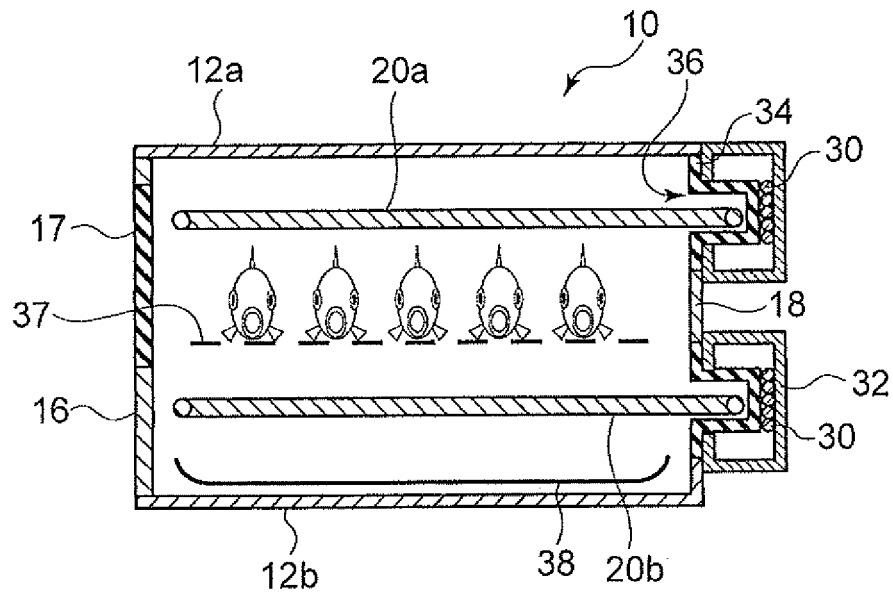


Fig.16

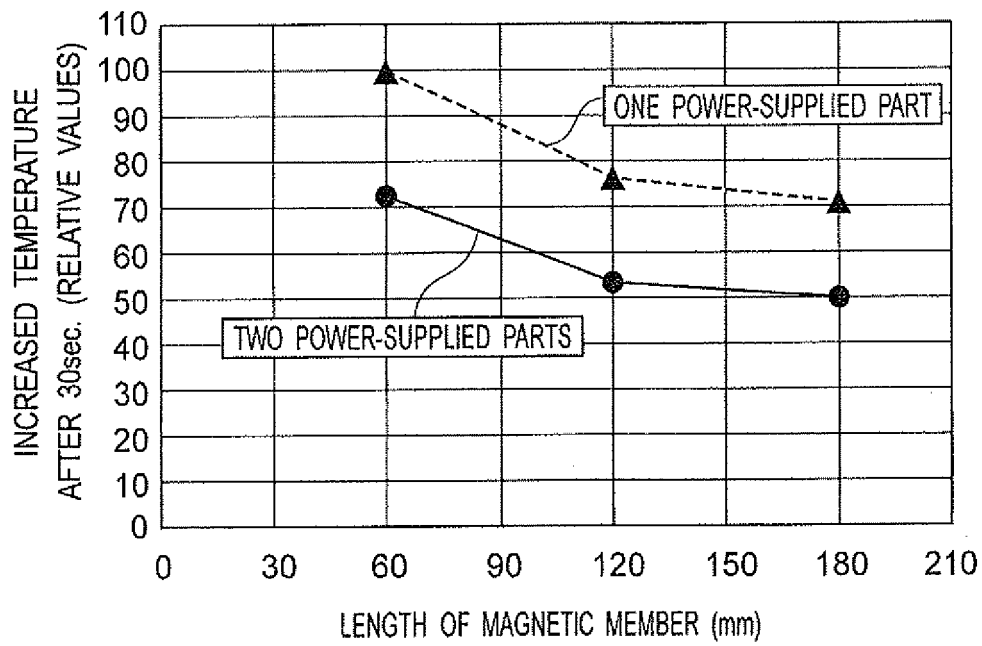


Fig.17

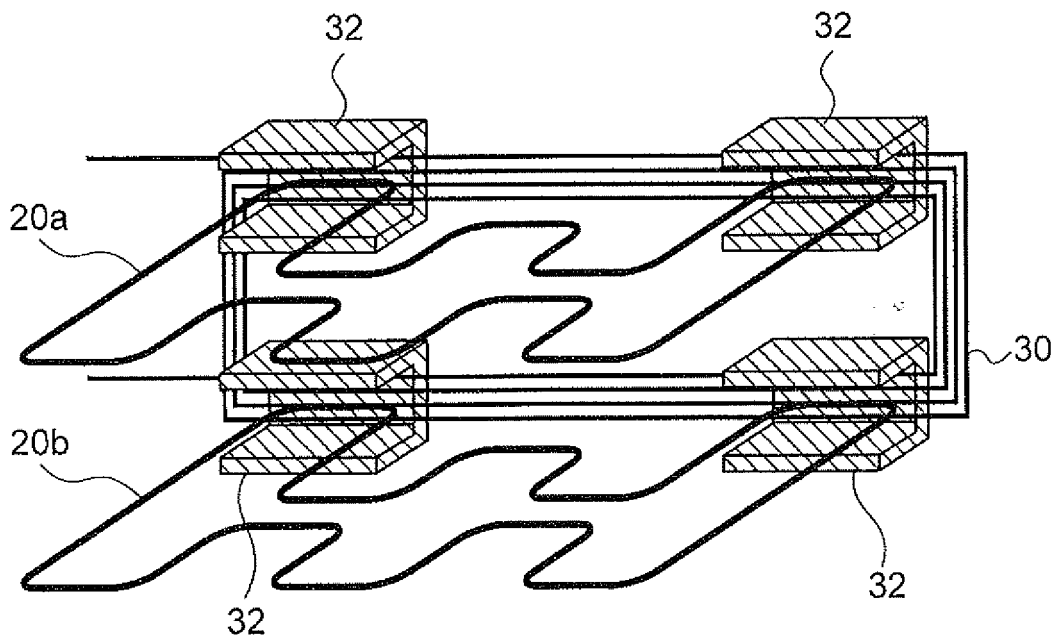


Fig. 18

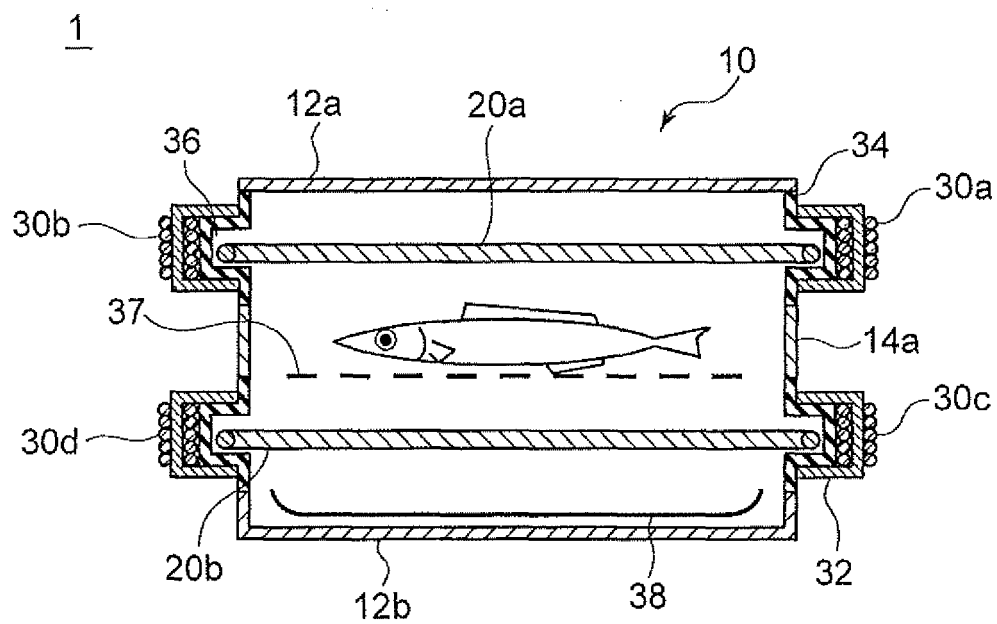


Fig. 19

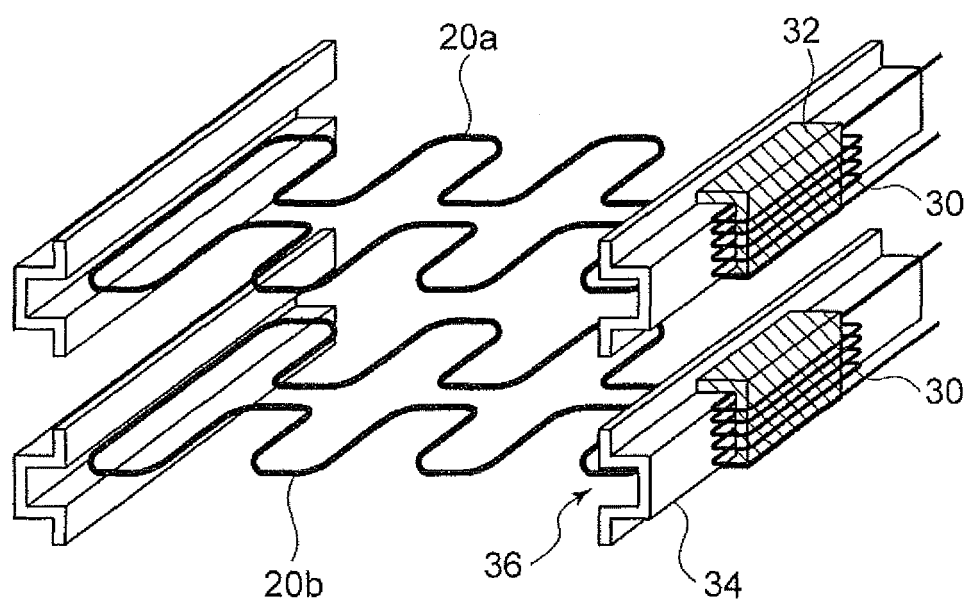


Fig.20

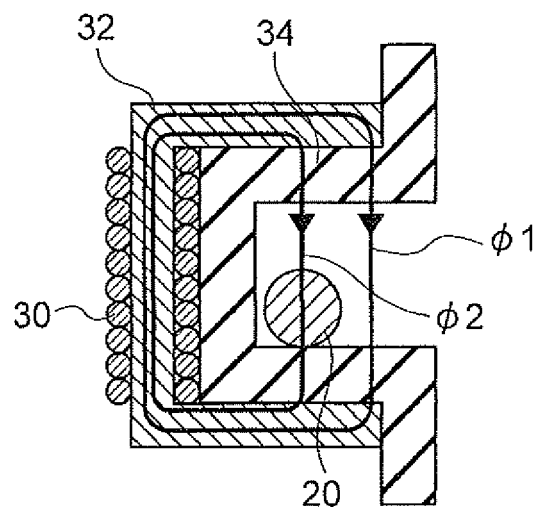


Fig.21

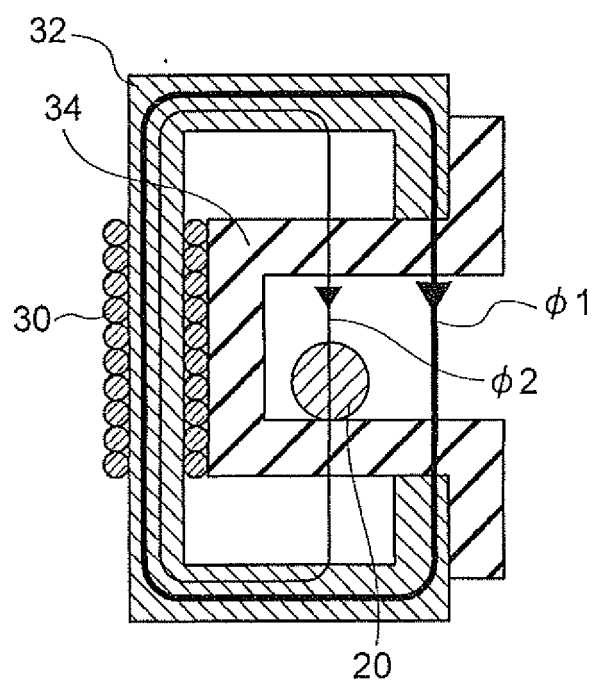


Fig.22

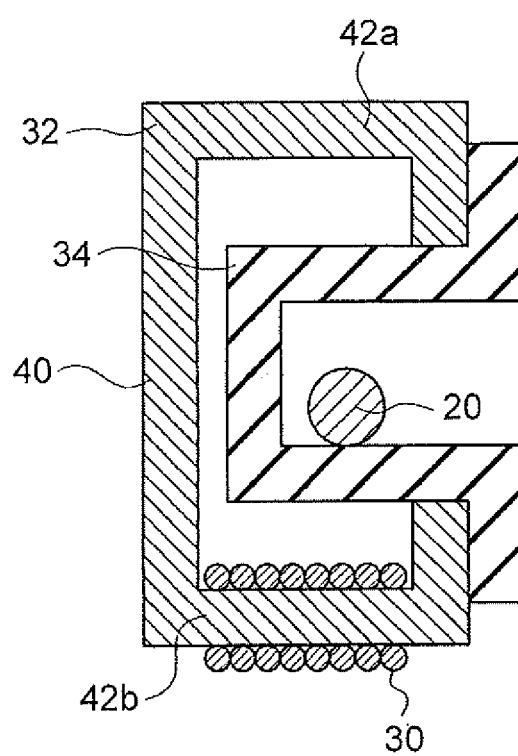


Fig.23

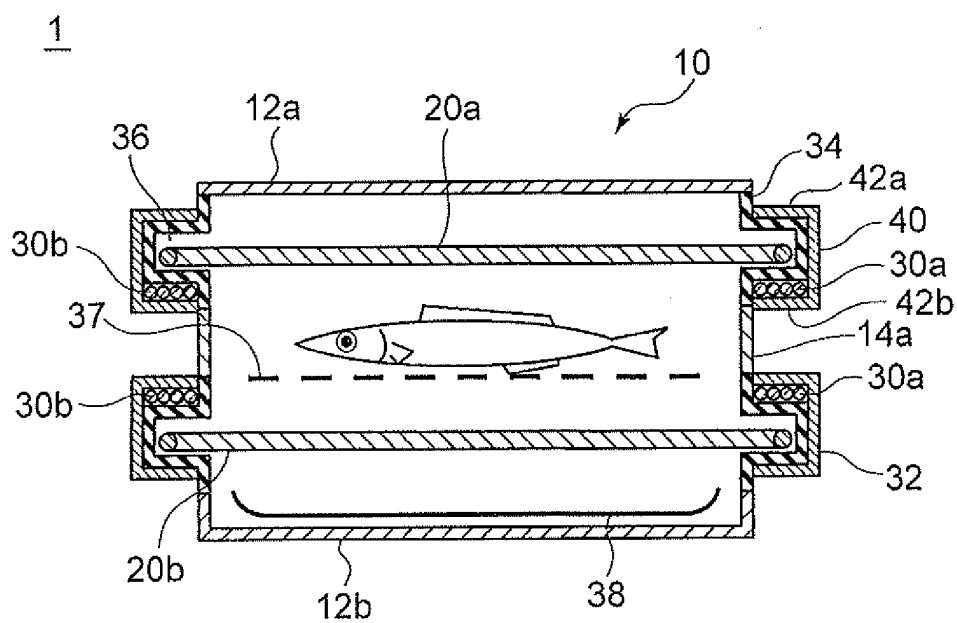


Fig.24

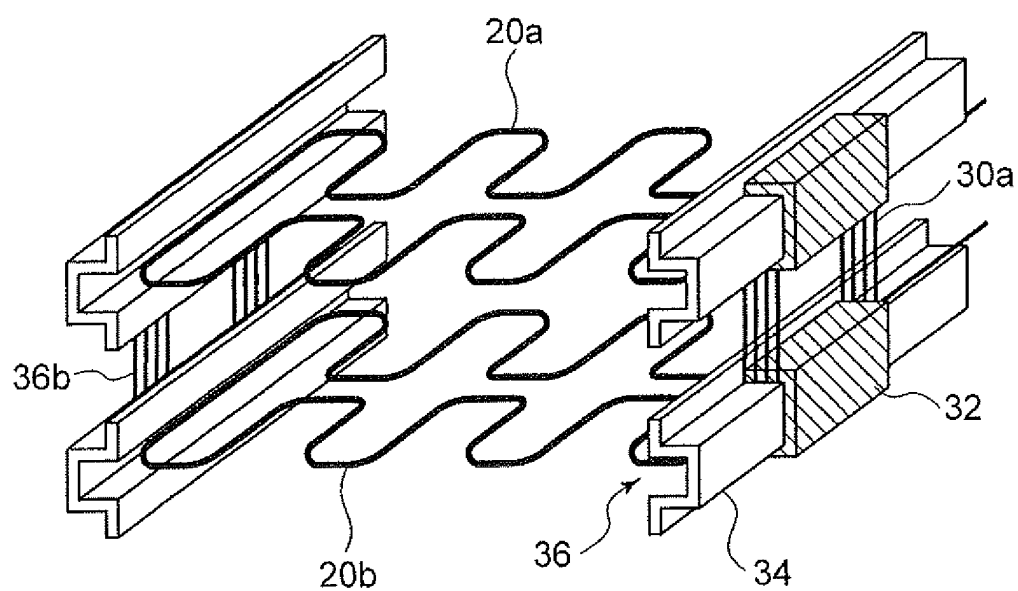


Fig. 25

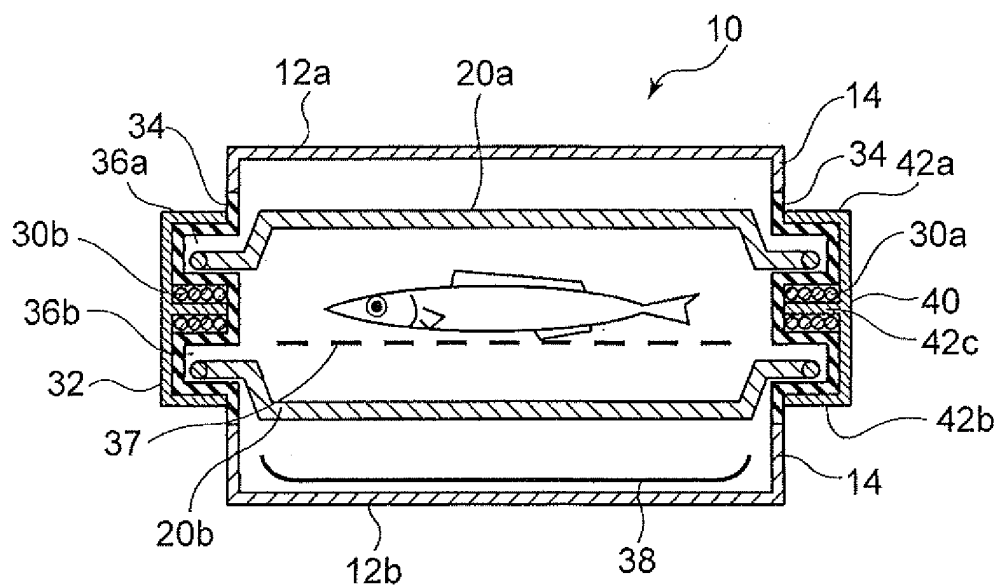


Fig.26

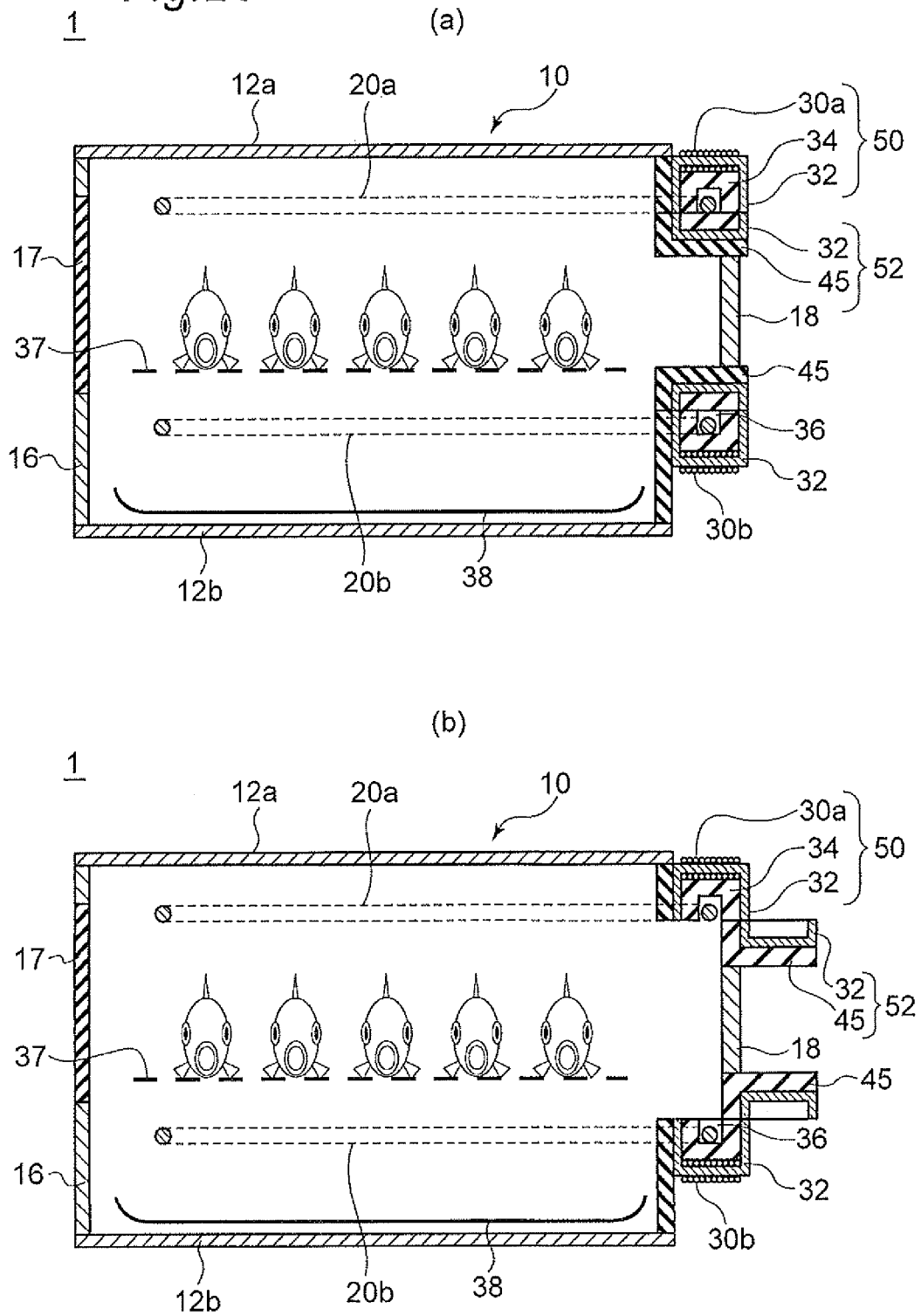


Fig.27

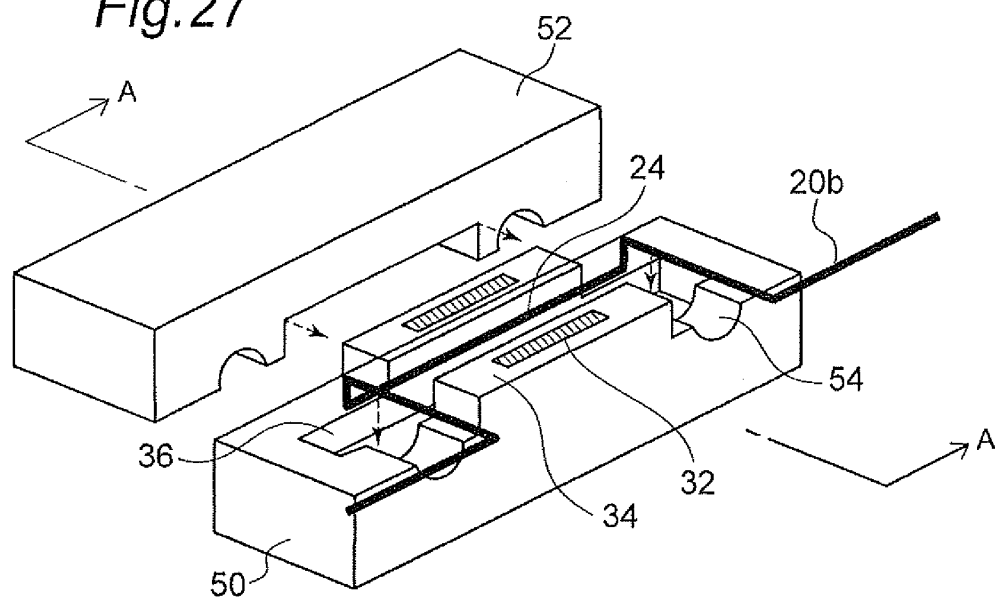


Fig.28

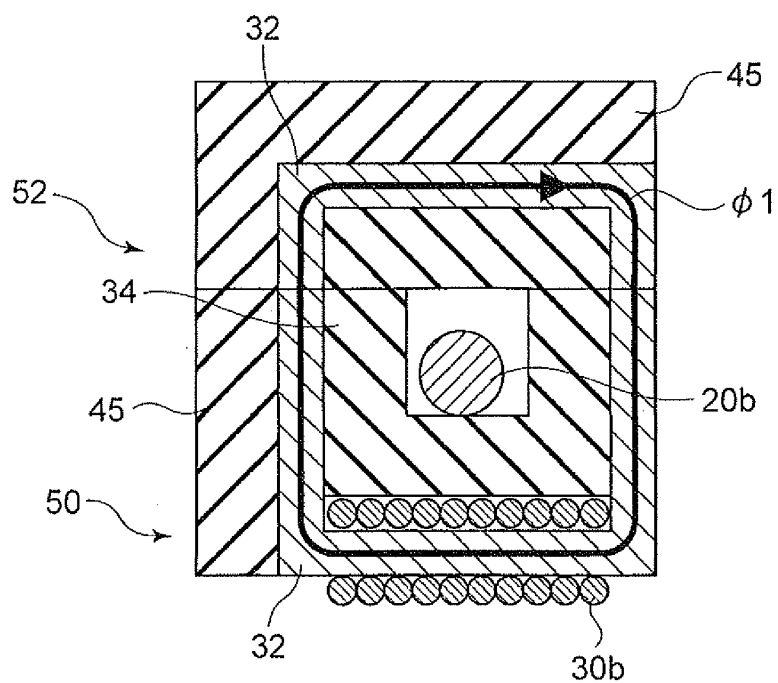


Fig. 29

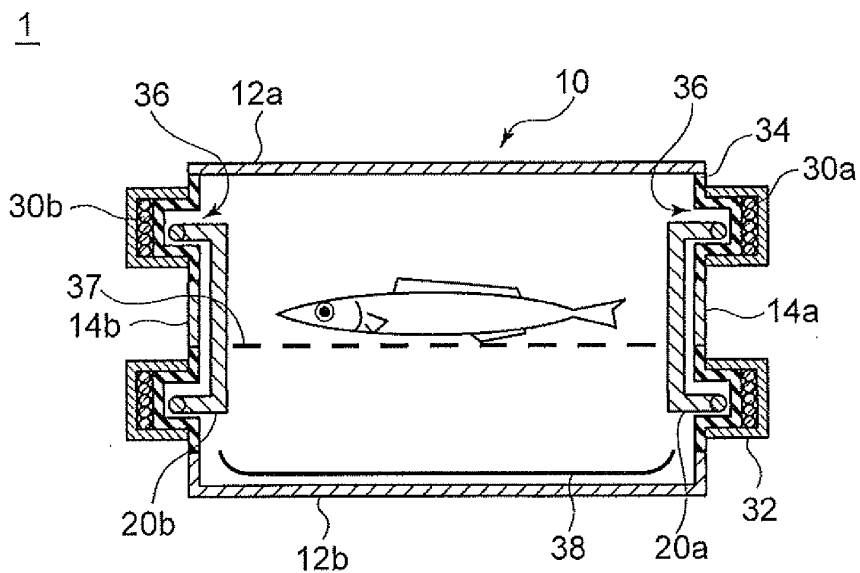


Fig. 30

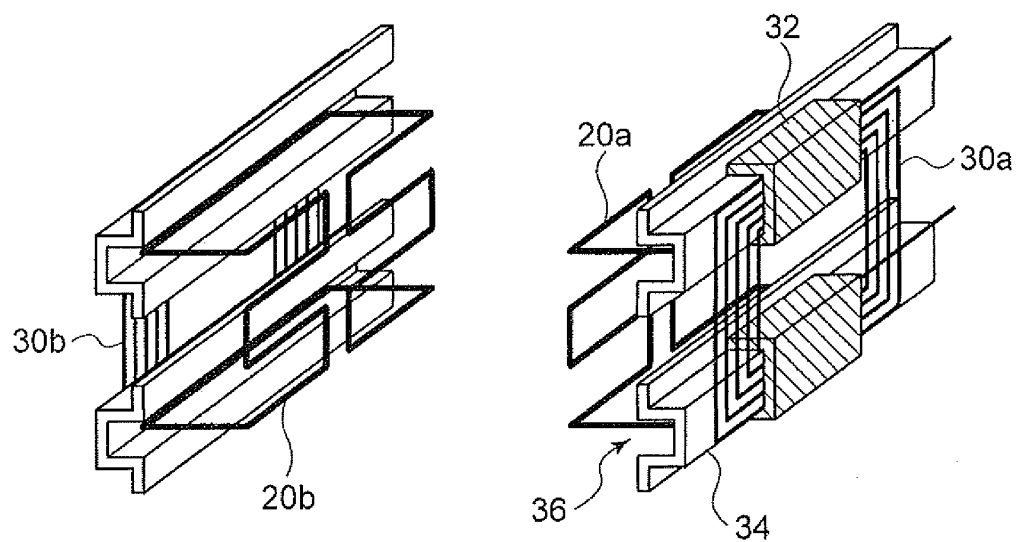


Fig.31

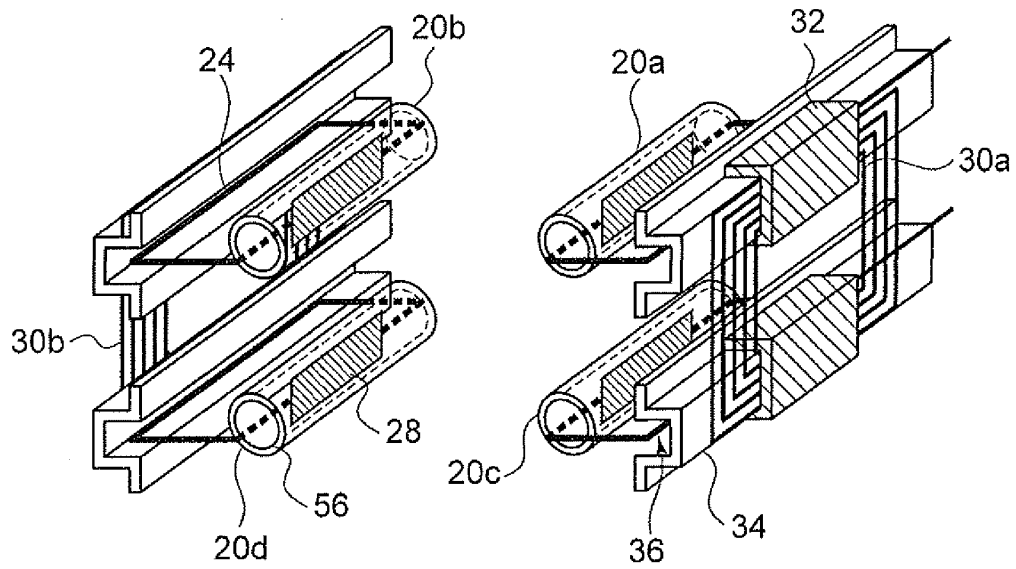


Fig.32

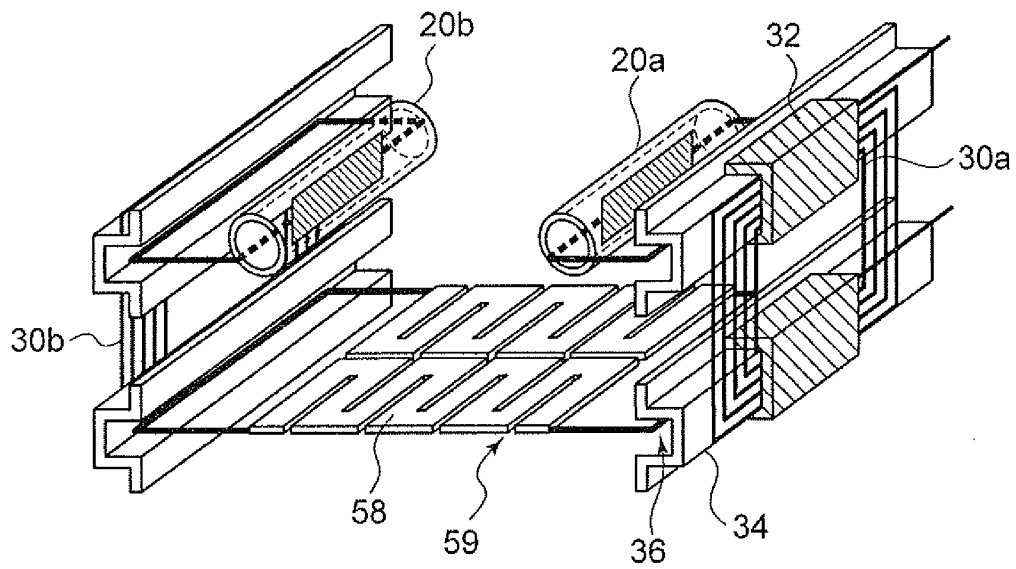


Fig.33

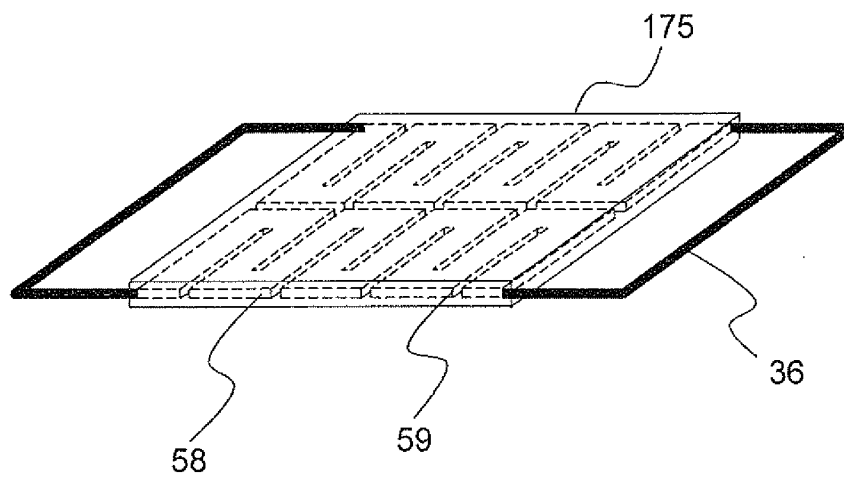


Fig.34

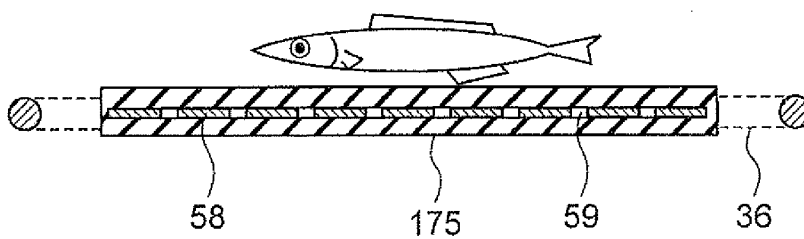


Fig.35

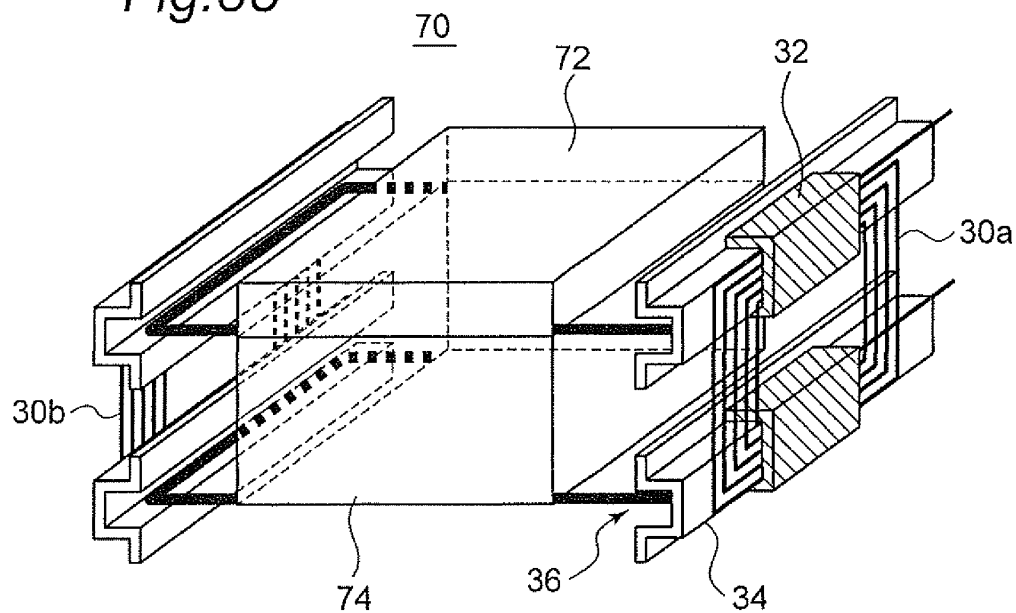


Fig.36

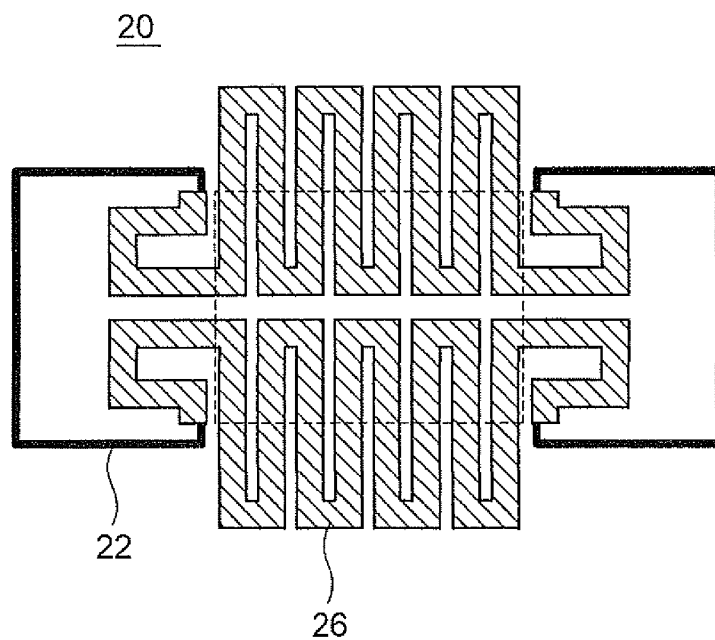


Fig.37

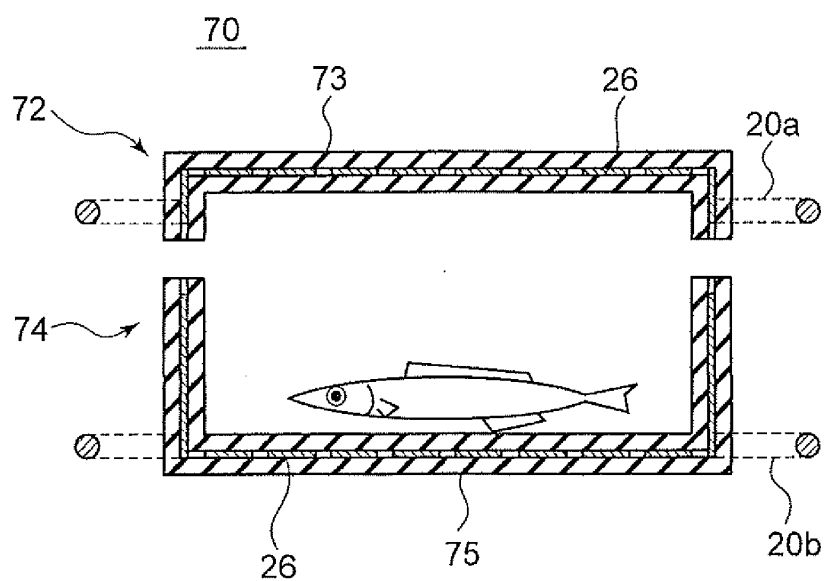


Fig.38

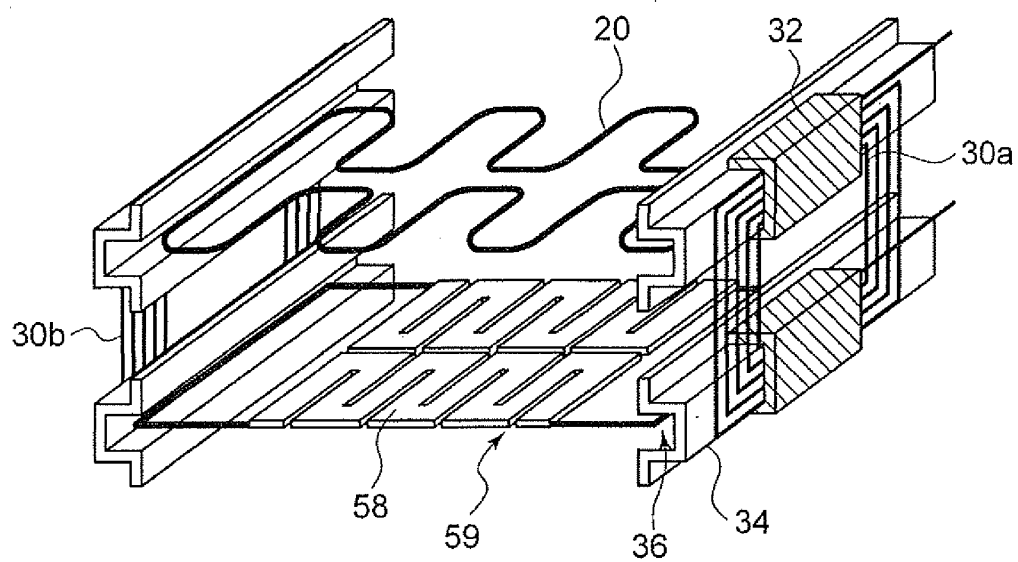
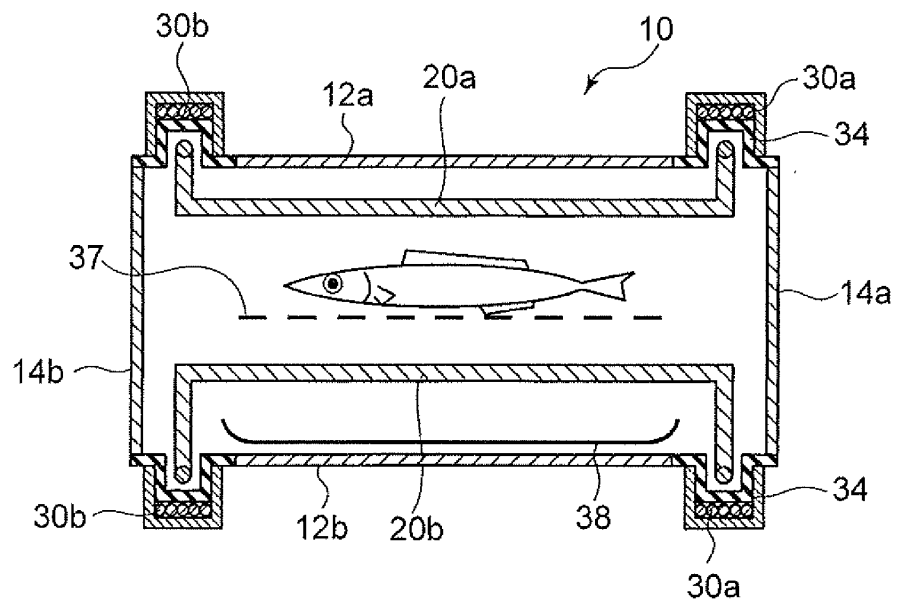


Fig.39



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/063556

A. CLASSIFICATION OF SUBJECT MATTER

F24C7/06(2006.01) i, H05B6/12(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)

F24C7/06, H05B6/12

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 6-163152 A (Matsushita Electric Industrial Co., Ltd.), 10 June 1994 (10.06.1994), paragraphs [0020] to [0024]; fig. 1 to 3 (Family: none)	1-3 4, 6, 10, 12-15, 17-21
Y	JP 4-341790 A (Mitsubishi Electric Home Appliance Co., Ltd.), 27 November 1992 (27.11.1992), paragraphs [0009] to [0013]; fig. 1, 2 (Family: none)	4, 6, 10, 12-15, 17-21

☒ 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
10 November, 2010 (10.11.10)Date of mailing of the international search report
22 November, 2010 (22.11.10)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/063556

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-235527 A (Matsushita Electric Industrial Co., Ltd.), 23 August 1994 (23.08.1994), paragraphs [0026] to [0028], [0034]; fig. 1, 3, 5 (Family: none)	6,10,12-15, 17-21
Y	JP 4-36981 A (Matsushita Electric Industrial Co., Ltd.), 06 February 1992 (06.02.1992), page 1, lower left column, lines 13 to 15; page 2, lower right column, line 5 to page 3, upper left column, line 6; fig. 1, 2 (Family: none)	12-15,17-21
A	JP 54-30548 A (Hitachi Netsu Kigu Kabushiki Kaisha), 07 March 1979 (07.03.1979), entire text; all drawings (Family: none)	1-4,6-21
E,A	JP 2010-178815 A (Mitsubishi Electric Corp.), 19 August 2010 (19.08.2010), entire text; all drawings (Family: none)	1-4,6-21

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/063556

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:

Document 1: JP 6-163152 A (Matsushita Electric Industrial Co., Ltd.), 10 June 1994 (10.06.1994), paragraphs 0020 - 0024, fig. 1 - 3

The inventions in claims 1 - 3 cannot be considered to be novel in the light of the invention described in the document 1, and do not have a special technical feature.

The invention in claim 4 has a special technical feature. Consequently, the inventions in claims 5 - 21 having no special technical feature do not comply with unity of invention.

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.: 1 - 4, 6 - 21

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the 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.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003282221 A [0004]
- JP 8138864 A [0005]
- JP 6018044 A [0006]