(12) UK Patent Application (19) GB (11) 2 232 346 (13) A

(43) Date of A publication 12.12.1990

(21) Application No 9007916.1

(22) Date of filing 06.04.1990

(30) Priority data
(31) 01041361 (32) 07.04.1989 (33) JP

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(51) INT CL^5
A47J 37/06, F24C 15/20

(52) UK CL (Edition K)
A4D D10B1

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(58) Field of search
UK CL (Edition K) A4D D10B1
INT CL^5 A47J
WPI (DIALOG)

(54) **Infrared oven**

(57) An infrared oven comprises a cooking chamber (18), a plurality of infrared heaters (3) arranged therein, and a means (11) for supporting food materials to be cooked. The cooking chamber is provided with at least one opening (7) to allow the cooking chamber to communicate with atmosphere, and a means (9), e.g. a fan, for forcedly exhausting air in the cooking chamber to the atmosphere through the opening.

Fig. 1

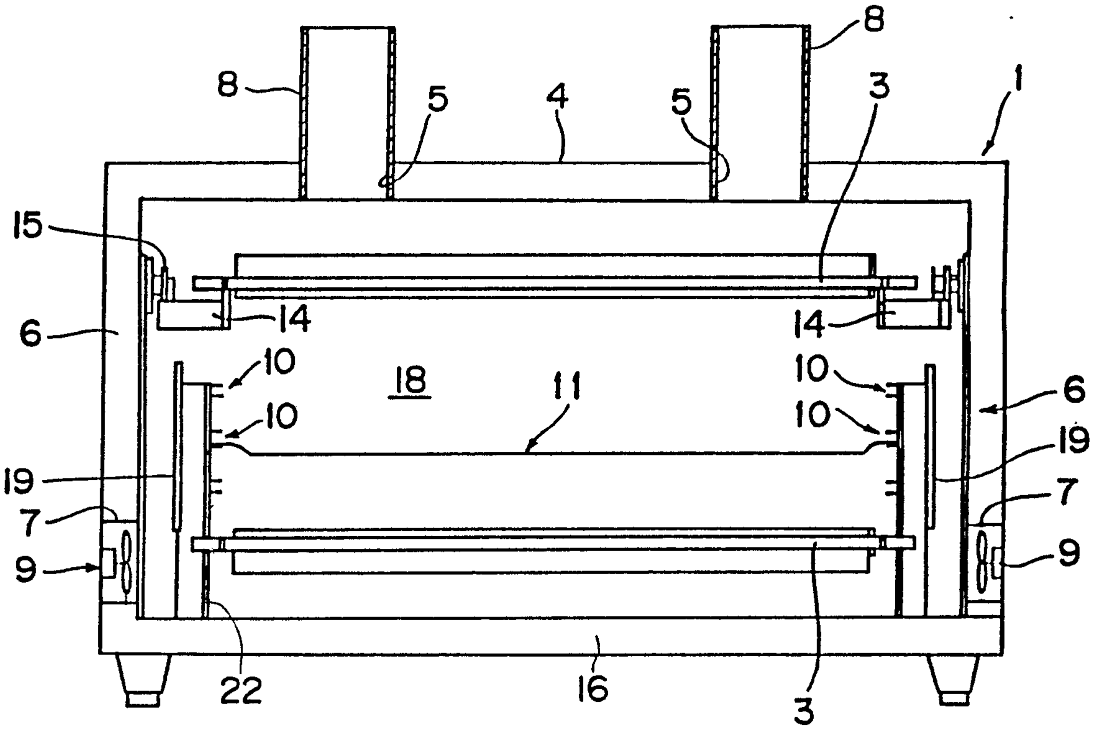

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Fig. 1

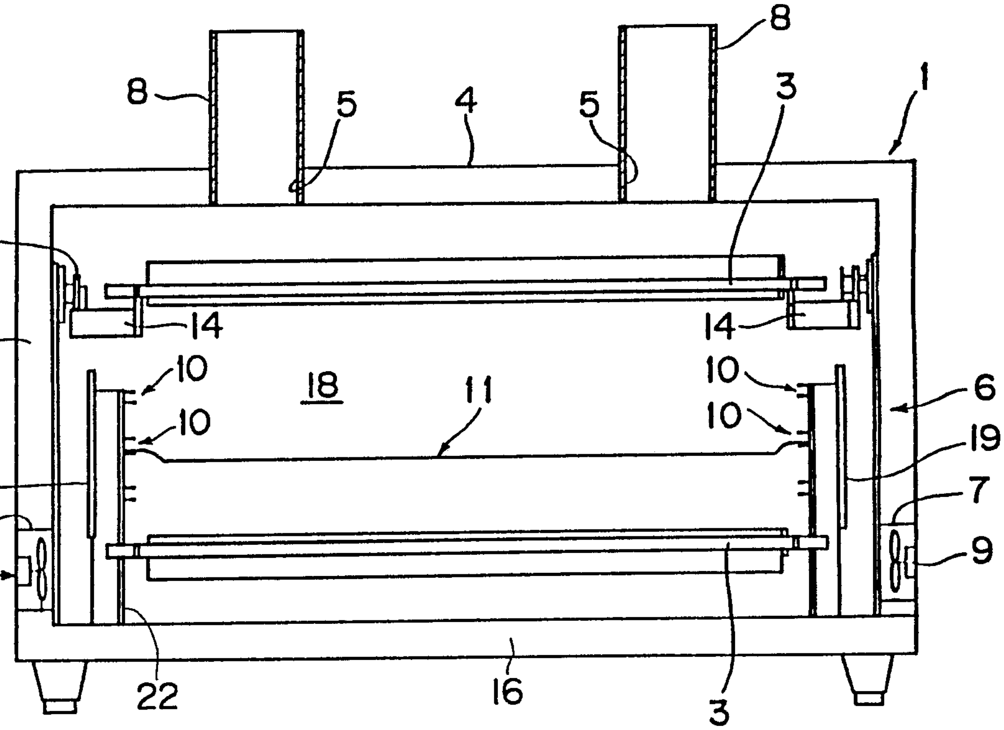
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Fig. 2

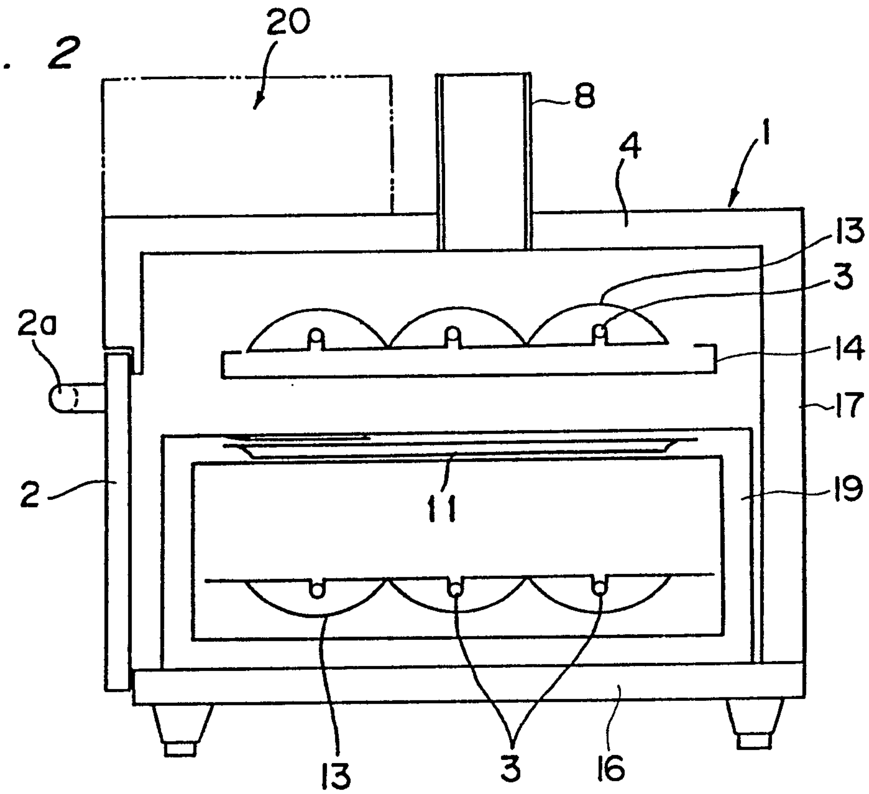
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Fig. 3

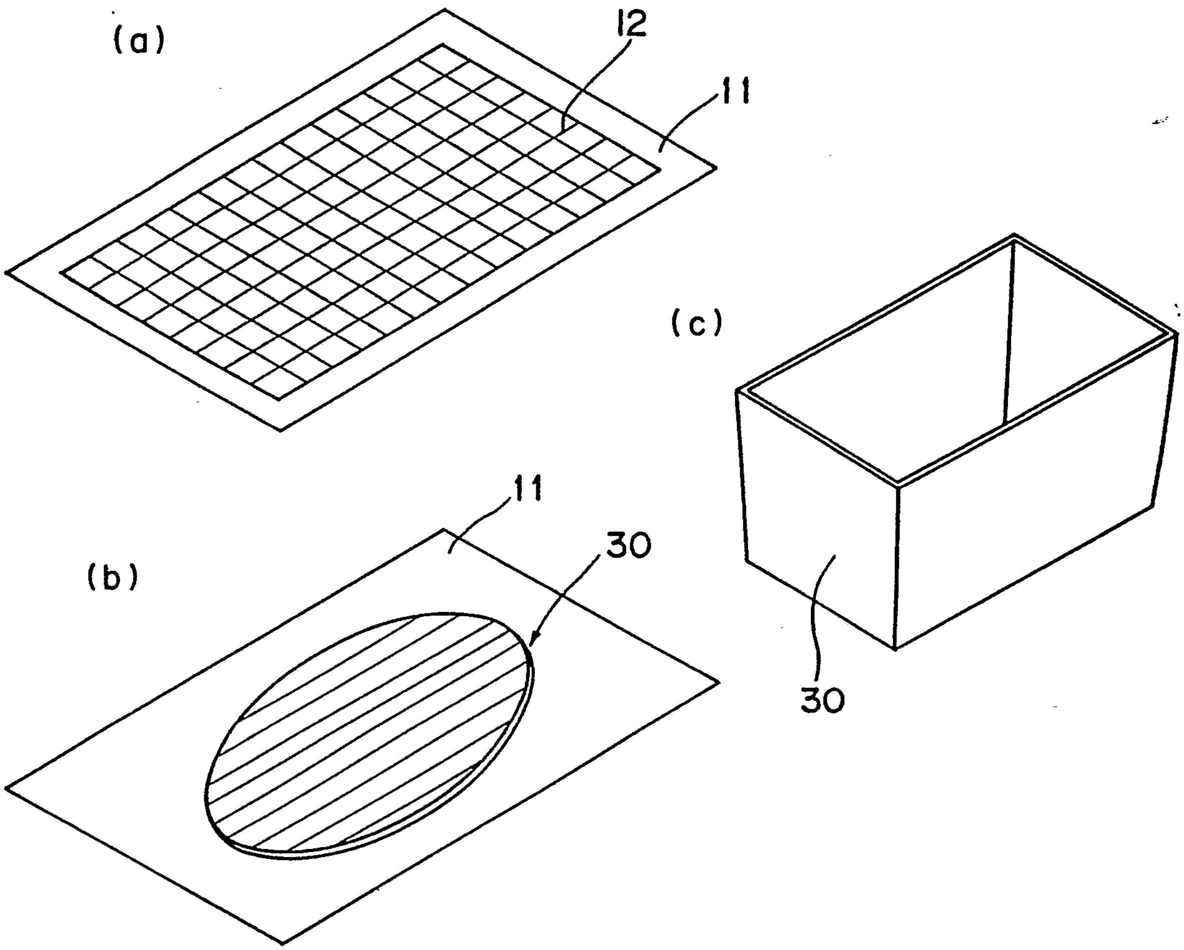


Fig. 4

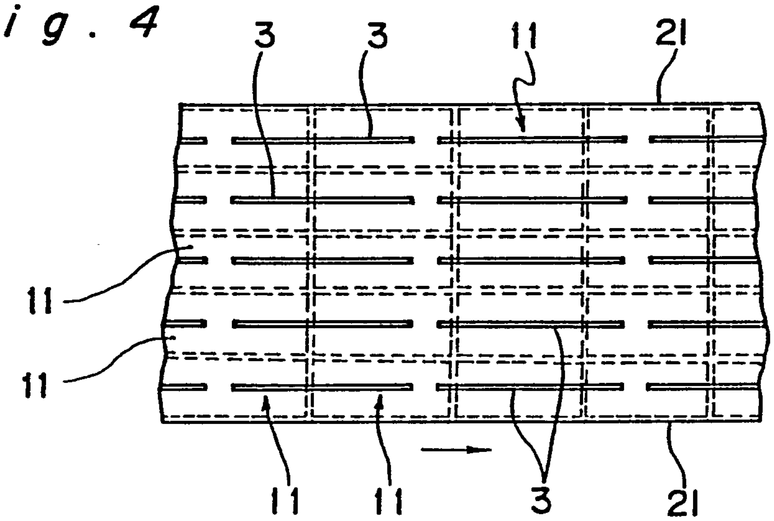
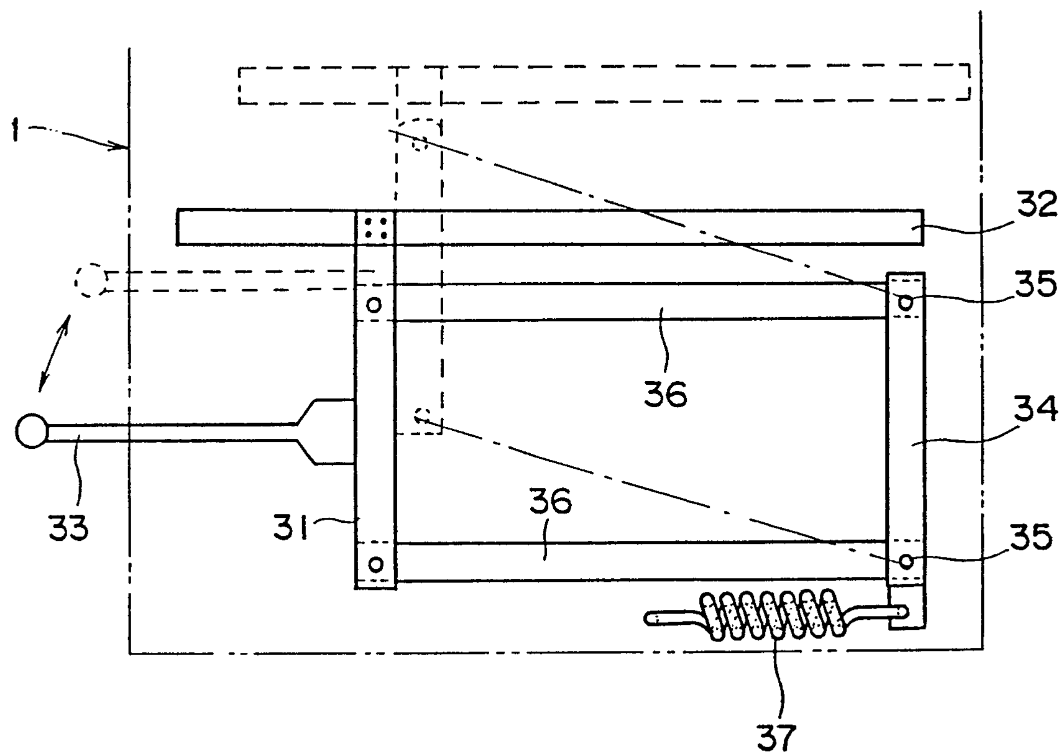


Fig. 5



"INFRARED OVEN"

The present invention relates to an infrared oven and, more particularly, to an infrared oven for heating or cooking food materials with infrared heaters.

In well-known electric ovens, a food material to be cooked is put into its cooking chamber maintained at a temperature of about 150 to 250°C by heating it with one or more electric heaters, and then left alone until the end of the previously determined cooking time. The food material is mainly heated by conduction and its surface is allowed to stand in contact with the hot air in the chamber maintained at that high temperature. If the food materials such as fish, meat and fowl are cooked with the electric ovens, they are broiled hard and lose flavour because of thermal degeneration of proteins thereof, dripping of meat juices and the like.

For such reasons, infrared rays, especially, infrared rays with relatively long waves have attracted special interest recently. When infrared radiation, especially, far infrared radiation is applied to cooking, the infrared rays penetrate into the interior of the food material and are absorbed directly by the food material, allowing the food material to generate heat by itself. Thus, the food material is broiled at low temperature, without causing the thermal degeneration of proteins and dripping of meat juices, which in turn makes it possible to obtain very softly broiled food with good taste.

However, for practical application of infrared heating, there are some difficult problems to be solved. For example, from the standpoints of sanitation and safety, an infrared oven is required to have a cooking chamber similar to that of the conventional electric ovens. If infrared heaters are arranged in such a cooking chamber, the chamber is heated and maintained at a temperature of about 160 - 200°C as it is relatively airtight. Thus, the food material to be cooked is heated by conduction rather than by infrared radiation, resulting in loosening of the original effects of infrared heating. In addition, water evaporated from the food material is closed in the cooking chamber so that infrared rays are absorbed by the vapour in the chamber, resulting in considerable lowering of the heating efficiency by infrared radiation.

It is a general object of the present invention to provide a new infrared oven for cooking food materials.

Another object of the present invention is to provide an infrared oven which makes it possible to cook food materials by infrared radiation, without causing considerable temperature raise of its cooking chamber and lowering of heating efficiency.

These and other objects are accomplished in an infrared oven in which a cooking chamber is provided with at least one opening to allow the cooking chamber to communicate with atmosphere, and a means for forcedly exhausting air in the cooking chamber to the atmosphere through said opening.

By operating the forced air-exhausting means, the hot air in the cooking chamber is exhausted together with water vapour to the atmosphere through said opening and external cool air is introduced into the cooking chamber through another opening or gaps formed in an oven body. Since the hot air in the cooking chamber is continuously exchanged for the cool one little by little, it is possible to maintain the cooking chamber at a temperature of not more than 120°C.

The forced air-exhausting means generally comprises a power-driven fan such as a suction fan, an exhauster and the like. The fan may be arranged in or just before the opening. If the fan is used to supply external cool air to the cooking chamber having an opening, the hot air in the chamber may be exhausted through gaps formed between an oven body and a door hinged thereto. In contrast therewith, if the fan is used to exhaust the hot air from the cooking chamber having an opening serving as the exhaust port, external cool air may be introduced into the cooking chamber through gaps formed between the oven body and door.

However, it is preferred that the oven body is provided two or more openings. When the oven body has two openings, one opening is used as an exhaust port, while other opening is used as a suction port. The opening serving as the exhaust port is preferably provided in a top wall or an upper part of the side or back wall of the oven body so that the opening is positioned at a level higher than that of a support shelf on which a food material to be cooked is placed. In this case, it is preferred to provide one or more openings serving as the suction port in a lower part of the side or back wall of the cooking chamber. Since the openings are not required to have a large size in diameter, the opening may be replaced with a plurality of small holes.

In the infrared oven of the present invention, the hot air in the cooking chamber is forcedly exhausted by the fan through the opening and the external cool air is supplied to the cooking chamber through another opening. For this reason, the cooking chamber is maintained at a temperature of not more than 120°C, generally, 50-95°C, thus making it possible to heat the food material mainly by the infrared radiation. In addition, the infrared rays is prevented from being absorbed by water vapour as the moisture in the cooking chamber is exhausted together with the hot air by the fan, thus making it possible to heat the food material at high efficiency.

The present invention will now be described in greater detail by way of examples with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic sectional front view of an infrared oven embodying the present invention;

Fig. 2 is a sectional side view of the infrared oven of Fig. 1;

Fig. 3 shows various browning members used in combination with the infrared oven of Fig. 1;

Fig. 4 is a partial cut-away plan view of an infrared oven showing another embodiment of the present invention; and

Fig. 5 is a side view of a supporting mechanism for adjusting the height of a shelf on which a food material to be cooked is mounted.

Referring now to Figs. 1 and 2, there is shown an infrared oven embodying the present invention, which comprises an open-sided, box-like oven body 1 with a front door 2, a plurality of infrared heaters 3 arranged in the oven body 1, and a power control system 20 mounted on the body 1.

The oven body 1 is provided in its interior with a cooking chamber 18 defined by a top wall 4, a pair of opposed side walls 6, a bottom wall 16 and a rear wall 17. The front of the body 1 is closed by the front door 2 which, in its closed position, constitutes a front wall of the cooking chamber 18. The door 2 is provided with a handle 2a and hinged to the front side of the bottom wall 17 to allow for easy access to the cooking chamber 18. The top wall 4 of the body is provided with two openings 5, into which exhaust pipes 8 are respectively fixed, to allow the cooking chamber 18 to communicate with the atmosphere.

The lower part of each side wall 6 is provided with an opening 7 to allow the cooking chamber 18 to communicate with the atmosphere. Within each opening 7, there is arranged a motor-driven fan 9 to introduce the external cool air into the cooking chamber 18 through the opening 7. The fans 9 may be arranged in or just before each opening 5 or both of the openings 5 and 7. In such a case, the fan arranged in or just before the opening 5 serves as an exhaust fan.

The infrared heaters 3 are in the form of a rod or bar and are arranged at the upper and lower areas of the cooking chamber 18 so that they extend in parallel between opposed side walls 6 and further along the top and bottom walls respectively. At the backside of each infrared heater 3, there is arranged a reflector 13 with an arc-shaped cross section so as to reflect the infrared rays directed to the top or bottom wall towards the food material and to make the flux of infrared rays parallel. The upper heaters 3 are fixed to the opposed side walls 6 with attachment members 14 and 15, whereas the lower heaters 3 are fixed to the bottom wall 16 by two pairs of upwardly extending supports 22 which are arranged at the respective corners of the bottom wall 16 of the body 1.

The supports 22 in each pair are provided with three guide members 10 to support a shelf 11 at various heights. The guide members 10 are respectively provided with a groove with a rectangular cross section, and the shelf 11 is removably inserted into the opposed grooves.

The shelf 11 is made up of a metal such as, for example, iron, cast iron, iron-based alloys, aluminum and the like in the form of a tray-like plate. The shelf 11 may be formed into a wire netting, vessel or like. The shelf 11 is coloured black so that it has the permeability of 0.1 to 1.0 and allows the infrared rays to pass therethrough. The distance between the shelf 11 and the lower or upper infrared heaters 3 may be adjusted by inserting the shelf 11 into the opposed grooves of the guide members 10 arranged at different heights.

If the food material is required to be broiled brown, it is preferred to use a support shelf 11 provided with projections 12 in the form of a wire-netting, lattice, or any other patterns, as shown in Fig. 3. It is also possible to use a separate browning member 30 in the form of a wire-netting, lattice, box-shaped vessel or any other shapes (Fig. 3b,3c), in combination with the flat shelf 11 of a plate or wire-netting. The separate browning member is generally made of iron, cast iron or an iron-based alloy. Best results are obtained when the browning member 30 is coloured black.

The infrared oven further comprises secondary infrared radiating plates 19 each being arranged between the side wall 6 and the end of the infrared heaters 3 to prevent the food material from underdone or undercooked when it is positioned near the side wall 6. The secondary radiating plate 19 is made up of a well-known infrared radiating ceramics such as, for example, zirconia, or the like.

The power control system 20 includes temperature sensors (not shown) such as, for example, thermocouples, thermistors and the like, for detecting the temperature of the cooking chamber 18 or surface temperature of each infrared heater 3. The control system 20 controls the electric power to be supplied to each heater 3 and electric fans 9 in response to signals from the sensors to maintain respective temperatures of the cooking chamber 18 and heaters 3 constant. The electric circuit of such a power control system is well known to those skilled in the art, there would be no need to provide further detailed description.

In operation, a food material is placed on the shelf 11 and then the heaters 3 are applied with power and controlled by the control unit 20 so that the surface temperature thereof are maintained at a temperature of 200 to 500°C. The infrared heaters 3 radiate infrared energy at wave lengths between about 2±0.5 to 1000μm in the electromagnetic spectrum to heat the food material. At the same time, the secondary radiating plates 19 absorb a part of the infrared rays and then produce infrared energy at wave lengths longer than that of the heaters as the surface temperature thereof is lower than that of the heaters. Thus, the food material is heated directly by infrared radiation from the heaters 3 and secondary radiating plate 19.

With the lapse of time, the temperature of the cooking chamber rises step by step, but it is maintained at the predetermined temperature of not more than 120°C in the following manner. The temperature of the cooking chamber 18 is detected by the sensor and used as the input to the control system 20. Using the signal from the sensor, the control system makes a decision as to whether the temperature of the cooking chamber 18 is higher than the predetermined upper temperature limit. When the control system 20 has made such a decision that the detected temperature is higher than the upper temperature limit, for example, 90°C, it produces an electric output to supply power to the fans 9, thereby starting the fans 9 rotating. For this reason, the external cool air is sucked in the cooking chamber 18 through the openings 7, whereas the hot air therein is exhausted to the atmosphere through the pipes 8. At the same time, the water vapour which absorbs infrared rays is removed from the chamber. Thus, the food material is heated by infrared radiation at high efficiency.

Since the hot air in the chamber 18 is replaced for the cool one, the temperature of the cooking chamber 18 is lowered step by step. When the cooking chamber 18 reaches to the predetermined lower temperature limit, 85°c for example, the control system 20 produces an electric output to shut the fans 9 off until the cooking chamber 18 reaches to the upper temperature limit again.

The infrared heaters 3 are controlled by the control system 20 almost exactly like the fan 9 so that the surface temperature of each heater is maintained at the predetermined temperature of 200 - 500°C, for example, at 400°C. Thus, the infrared heaters 3 radiate infrared energy at wave lengths between about 2.0 to 1000μm in the electromagentic spectrum.

In the above embodiment, the electric fans are employed as the forced air-flow producing means, but may be removed from the over. In such a case, it is required to use one or more elongated ventilation ducts or pipes instead of the short pipes 8 to produce a convection current in the cooking chamber through the ducts or pipes.

The present invention may be applied to infrared ovens for industrial applications, as illustrated in Fig. 4. In this embodiment, a means for supporting food materials comprises a chain conveyor 21 travelling in the cooking chamber, and one or more shelves 11 fixed or removably mounted thereon.

In general, there is a large difference in the amount of infrared radiation between both ends and middle of each heater. If such infrared heaters 3 are arranged in a row so that they extend in the direction perpendicular to the travelling direction of the shelves 11, the distribution of infrared rays is localized to the middle part of the cooking chamber, thus making it impossible to heat the food material uniformly. To solve this problem, the infrared heaters are arranged in several lines so that they extend in the direction parallel to the travelling direction of the shelves 11, as shown in Fig. 4. Such an arrangement of infrared heaters makes it possible to achieve uniform heating of the food material. It is preferred to use shelves which have the same width as that of the reflectors 11, as illustrated by broken lines in Fig. 4.

In the above embodiment, the shelf 11 is removably mounted on one of three pairs of the guide members 10 fixed to the supports 22 at three different heights, but may be so arranged in the cooking oven that it is moved up and down by means of a supporting mechanism comprising a driving means such as, for example, a pneumatic cylinder, a power-drive rack-and-pinion and the like. For example, such a supporting mechanism may be constructed as shown in Fig. 5.

In the embodiment of Fig. 5, the supporting mechanism comprises a pair of parallel crank mechanisms arranged on opposed sides of the cooking chamber, each crank mechanism comprising a pair of links 31, 34 and a pair of arms 36 pivotally mounted on upper and lower portions of the links 31,34. The front link 31 is provided at its top with a supporting frame 32 for support of the shelf 11, and at its front side with a control lever 33. The lower arm 36 may be of an L-shaped member and be connected to the side wall of the cooking chamber 18 by a coil spring 37 so that it is forced to rotate clockwise round the pin 35 in Fig. 5.

In operation, with lifting the lever 33, the arms 36 are rotated round the pins 35 and the supporting frame 32 is moved upwardly as illustrated in Fig. 5 by broken lines, thus making it possible to adjust the height of the shelf mounted on the supporting frame 32 with ease by the operation of the lever 33.

Example 1

Using an infrared oven of Fig. 1, a saurel with 230g in weight was broiled for 10 minutes in the following manner: the distance between upper and lower heaters is set to 20cm, and the shelf 11 of a wire netting is arranged in the middle of a space formed between the upper and lower heaters. The saurel is placed on the wire netting shelf 11, and then a power switch is turned on to put the infrared oven to work. In operation, the surface temperature of each upper infrared heater 3 is maintained at a temperature of 500°C, whereas the surface temperature of each lower infrared heater 3 is maintained at a temperature of 450°C. At the same time, the cooking chamber is maintained at 95°C by the fans 9. The broiled saurel was 202g in weight (yield: 88%). The sampling showed that the fish meat is easily separated from the bone, is soft and tastes nice.

Comparative Example 1

A saurel 225g in weight was broiled in the same manner as above, except for that the cooking chamber was maintained at 135°C. The broiled saurel was 178g in weight (yield: 79%). The sampling test showed that the fish meat has grown hard a little and is relatively dehydrated.

Comparative Example 2

A saurel was broiled in the same manner as Example 1, except for that the fans are held stop during broiling. The temperature of the cooking chamber reached to 160°C, and the yield and taste of the broiled fish were the same as those of saurel broiled by the conventional electric oven.

Example 2

An eel (106g) was broiled for 7 minutes in the following manner: the eel was skewered and placed on the wire-netting shelf. Electric power is applied to the infrared oven. During operation, the surface temperature of each upper infrared heater 20 is maintained at a temperature of 450°C, whereas the surface temperature of each lower infrared heater 3 is maintained at a temperature of 400°C. The cooking chamber was maintained at 87°C by the fans 9.

The broiled eel was 102g in weight (yield: 96%). Sampling test showed that the eel possesses good separation from the skewer, has a soft skin and tastes nice.

Comparative Example 3

A eel (104g) was broiled in the same manner as above, except for that the cooking chamber was maintained at 120°C. The broiled eel was 88.5g (yield: 85%). Sampling test showed that the broiled eel possesses bad separation from the skewer, has a skin grown hard and tastes flat.

As can be seen from the above results, according to the present invention, the cooking chamber is maintained at temperatures of not more than 120°C as the hot air in the chamber is forcedly exhausted by the electric fan, thus making it possible to obtain the excellent heating effects of infrared radiation. Further, it will be seen that heating by infrared rays provides best results when the food materials such as fish, flesh and fowl are broiled at a temperature of not more than 120°C, preferably, a temperature of 50 to 95°C. In contrast therewith, the increasing temperature of the cooking chamber causes thermal deformation of protein, resulting in lowering of taste and yield even if infrared heaters are employed as a heat source.

CLAIMS

1. An infrared oven comprising a cooking chamber, a plurality of infrared heaters arranged in said cooking chamber, and a means for supporting food materials to be cooked, characterized in that said cooking chamber is provided with at least one opening to allow the cooking chamber to communicate with atmosphere, and a means for forcedly exhausting air in the cooking chamber to the atmosphere through said opening.

2. An infrared oven claimed in claim 1 wherein said cooking chamber is provided with at least one opening serving as an exhaust port at a position higher than that of said supporting means.

3. An infrared oven claimed in claim 1 wherein said cooking chamber is maintained at temperatures of not more than 120°C by said forced air-exhausting means.

4. An infrared oven claimed in claim 1 wherein said infrared heaters are maintained at a temperature of 200 to 500°C so that they radiate infrared energy at wave lengths between about 2±0.5 to 1000μm in the electromagnetic spectrum.

5. An infrared oven constructed substantially as herein described with reference to and as illustrated in the

accompanying drawings.

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