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Tanizaki

[11] **3,783,220**

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[54] **METHOD AND APPARATUS FOR BROWNING EXTERIOR SURFACES OF FOODSTUFF IN AN ELECTRONIC RANGE**

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[30] **Foreign Application Priority Data**

July 6, 1970 Japan 45/58847

[52] **U.S. Cl.** **219/10.55,** 99/451, 219/543

[51] **Int. Cl.** **H05b 9/06**

[58] **Field of Search** 219/10.55, 543; 99/451

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[57] **ABSTRACT**

Browning the outer external surface of a foodstuff with infrared rays emitted from an infrared source at the same time the interior of the foodstuff is processed in an electronic range. The foodstuff and the source for emitting the infrared rays are placed in a region where electromagnetic waves are radiated from a high frequency generator. The infrared source is constructed by evaporating a conductive thin film on the outer surface of a dish or other vessel for holding the foodstuff. Alternately, crystallized glass having fine pieces of carbon fibres scattered throughout may form the infrared source. In yet another embodiment, a layer of silicon carbide may be formed on an insulating base plate. In each of the embodiments, the infrared heat is generated by the action of the electromagnetic waves on the specially constructed source.

10 Claims, 3 Drawing Figures

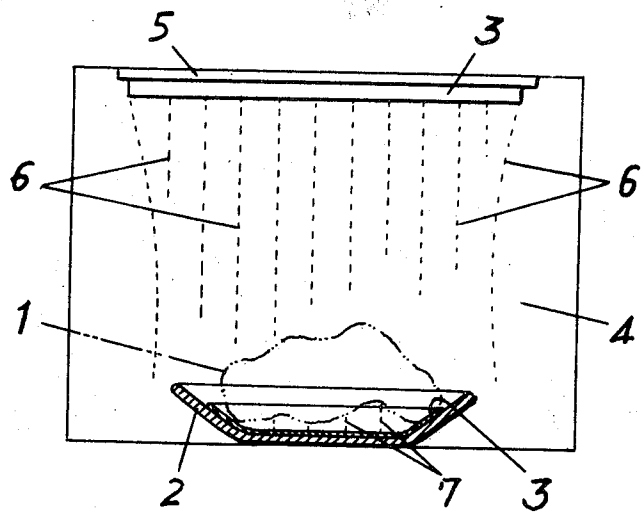


Fig. 1.

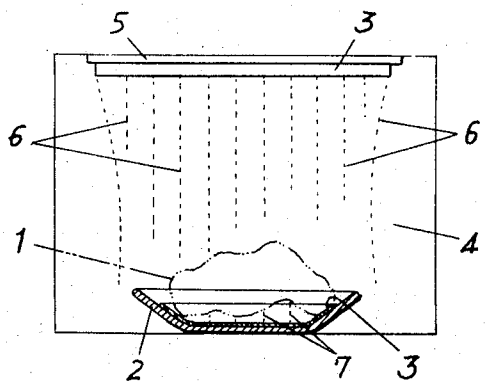


Fig. 2.

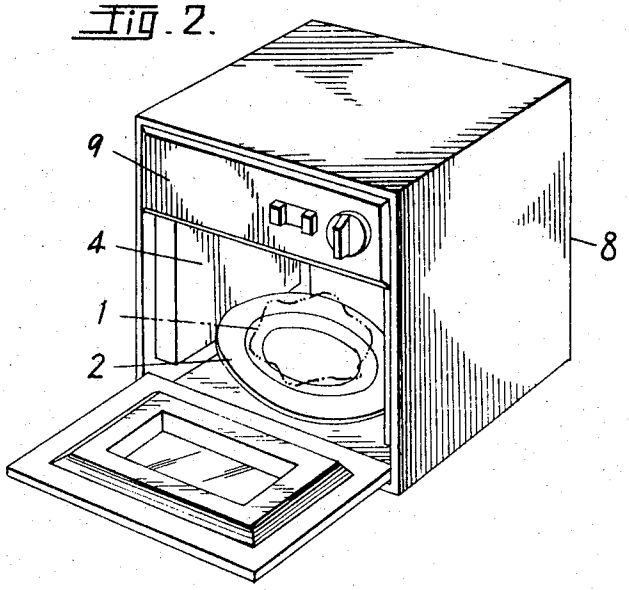
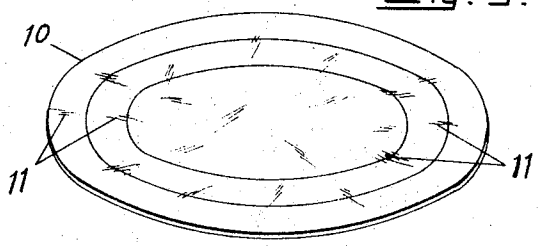


Fig. 3.



METHOD AND APPARATUS FOR BROWNING EXTERIOR SURFACES OF FOODSTUFF IN AN ELECTRONIC RANGE

BACKGROUND OF THE INVENTION

The invention relates to an apparatus and method for browning the exterior surfaces of a foodstuff in an electronic range by providing an additional infrared heating of the foodstuff as a phenomena of heating of a dielectric through high frequency.

When a foodstuff is roasted directly with a gas flame or is grilled by the radiation from a nichrome heater, the heating of the foodstuff goes on slowly from the exterior to the interior of the foodstuff. The exterior of the foodstuff may be done to the extent of scorching while the interior may remain in a state of half roasting. For example, a roast may be well done on the exterior while remaining rare in the interior.

In case of heating a foodstuff by an electronic range, the cause of heating is due to molecular motion in the interior of the foodstuff when it is subjected to high frequency electromagnetic radiation. According to the characteristic of high frequency dielectric heating, the foodstuff itself becomes a heat generating body and the interior and exterior thereof are cooked equally and swiftly.

However, according to the time honored custom, it is a matter of necessity from the point of view of taste, of sight and for general gastronomic appeal to have some browned portion on the outer surface of an individual serving of the food. In the above electronic range, it is impossible to obtain such browning of the outer portions as the interior and the exterior of the food is equally cooked.

OBJECTS OF THE PRESENT INVENTION

It is therefor a primary object of this invention to provide an apparatus for browning the exterior surface of a foodstuff while preparing same in an electronic range.

Another object of the invention is to provide a method and apparatus for heating the interior of the foodstuff sufficiently in a short time as well as simultaneously browning the exterior thereof.

Another object of the invention is to provide an infrared source generating body for use in an electronic range.

It is yet another object of the invention to provide a means of manufacturing a heat generating body for use in an electronic range to brown the exterior surfaces of foodstuffs processed therein.

The present invention provides an apparatus and method in which a source for emitting infrared radiation and a foodstuff to be heated are put in a region of propagation of electromagnetic waves emitted from a high frequency generator. The whole of the foodstuff to be heated is subjected to high frequency dielectric heating and at the same time, the exterior surface of the foodstuff is browned by the infrared radiation emitted from the infrared source.

DESCRIPTION OF THE DRAWINGS

The details of the present invention will be better understood from the following description and with reference to the accompanying drawings in which:

FIG. 1 diagrammatically illustrates the operation of the present invention;

FIG. 2 is a perspective view of an electronic range incorporating the present invention;

FIG. 3 is a perspective view illustrating an alternate embodiment of the heat generating source.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a conventional electronic range is illustrated in somewhat schematic form. A foodstuff 1 to be processed is placed in the heating chamber 4 of the range and is subjected to high frequency electromagnetic radiation (illustrated by the numeral 6) which is generated by a high frequency generator 9 (FIG. 2). The high frequency radiation 6 traverses the interior 4 of the range and acts upon the foodstuff 1 contained therein. As is well-known to those skilled in the art, molecular motion in the interior of the foodstuff causes heating and as a result the foodstuff itself becomes the heat-generating body. As mentioned above, foodstuff prepared in this manner is quickly and rapidly cooked and the interior and exterior surfaces are generally cooked to about the same degree.

In order to brown the outer surfaces of the foodstuff while simultaneously subjecting it to the high frequency electromagnetic radiation, a conductive thin film 3 may be formed on the surface of a dish or other vessel 2 in which the foodstuff is contained when placed in the oven. Alternately, an insulating plate 5 having a similar conductive thin film 3 thereon may be provided at an appropriate position in the heating chamber 4 of the electronic range.

In operation, an electronic vortex current is generated in the thin film 3 by the action of the electromagnetic waves 6 causing the thin film to heat and become an infrared heat source. Accordingly, the infrared radiation from the thin film 3 located on the dish 2 or on the insulating plate 5 radiates infrared radiation to thereby apply additional heat to the exterior surfaces of the foodstuff 1 at the same time the interior of the foodstuff is heated by the passage of the high frequency electromagnetic waves therethrough.

As mentioned above, the conductive thin film 3 may be formed on the surface of the dish 2 or on the insulating plate 5. In the case of a dish, it is preferable to provide a material such as glass having a low coefficient of expansion and heat resisting properties. A thin tin oxide coating is glazed at a high temperature to the surfaces of the dish thereby providing a conductive thin film on its surfaces. Alternately, a similar thin film layer of tin oxide may be provided on an insulating plate 5 at an appropriate location within the range. If the thickness of the layer 3 is about 0.5 μ the approximate resistance of the dish 2 or the insulating plate 5 will be on the order of 1.5×10^{-3} Ωcm. As a contrast, for example, the resistance value for copper is 1.7×10^{-6} Ωcm and, for nichrome, 1.1×10^{-4} Ω cm.

A conductive glass 3 constructed as above exhibits excellent performance when utilized as an infrared heat generating source in an electronic range. This is due to the combined effect of the electrical insulating properties of the glass itself and the electrical conducting properties of the coated film. If the region of wavelength is in the neighborhood of the maximum emissivity of infrared radiation is made to lie somewhere at more than 3 μ, there is little change in the heating effect as the surface color of the object varies during

cooking. Also, the efficiency of heat transfer radiation is high.

In the practice of the present invention, by forming a conductive thin film **3** on the dish itself no modifications are necessary to the range. The foodstuff is simply placed in the dish and the range is operated in a conventional manner. The coating on the glass may be transparent or attractively colored. The dish may also be utilized as a convenient serving dish.

It may, therefor, be seen that an infrared heat generator is supplied without the necessity of a separate electrical power source within the range. Similarly, the insulating plate **5** may be arranged in the range in any convenient manner so that it may be removed if desired. In either case, a separate power source is not required as the thin film conductive layer **3** provides the infrared heat source as the electromagnetic waves act upon it.

As is well-known to those skilled in the art, electronic ranges of the type herein described are instantaneous in their operation. The high frequency generator may be turned on or off as desired. Consequently, objects contained within the oven will instantly be subjected to very high frequencies and the resultant high temperatures. Conversely, the articles therein may be subjected to an abrupt cooling. Accordingly, conductive glasses used therein must be able to withstand these extreme variations and yet must effectively transfer the infrared radiation. The base of the conductive glass plate may, therefore, be prepared as follows:

The principal materials (SiO_2, Al_2O_3, Li_2O, etc.) are added with agents for nucleus formation (ZrO_2, TiO_2, etc.) and these are mixed completely. The mixture is then fused at a high temperature of about 1,600°C and, processed by molding it to the required shape and dimension. The molded shape is then annealed to remove stresses. The raw material at this stage of process remains amorphous and the finished product is obtained by giving primary heating (700°–800°C) continuously in an oven for crystallization to keep the original form of the raw glass. The glass is then subjected to a secondary heating treatment (800°–900°C).

The above primary and secondary heat treatments are the heating schedule based on the theory of generation and growth of crystals. At the first stage of the primary heat treatment, small nuclei having dimensions of from several ten to several hundred of A are generated, then after the elevation of the temperature amorphous regions are formed around the nuclei.

If the secondary heating state is held for 1–5 hours the above amorphous regions change to β-Eucryptite ($Li_2O.Al_2O_3.2SiO_2$) and M_pO and to microcrystals of solid solution of SiO_2.

Up to this stage of process the crystalline particles are less than 0.01 –0.5 μ, of smaller dimension than the wavelengths of visible rays and the index of refraction of light is the same as that of the glass. The transparent products are thereby obtained. If semi-transparent or white objects are desired further heating process may be applied.

The glass obtained by the above process is to be defined as a "crystallized glass".

In another embodiment, a conductive glass as shown in FIG. **3** may be provided. Fine pieces of carbon fibre **11** are sprinkled and adhered to a dish **10** formed of electrically insulating and heat-resisting glass, ceramic or the like.

The above carbon fibre **11** is a popular name for fibres of cellulose or acryl baked (carbonized) at a temperature exceeding 1,000°C on immersing them in nitrogen or alchol by isolating from oxygen.

In yet another embodiment, a layer of silicon carbide (SiC) may be formed as the thin film **3** on a dish using heat resisting glass or ceramic as the principal body. Because of its high melting point this embodiment operates satisfactorily in a high temperature environment.

Reasonable variations and modifications are possible within the scope of the foregoing disclosure, the drawings and the appended claims without departing from the spirit of the invention.

What is claimed is:

1. In an electronic range having a chamber in which a foodstuff is subjected to high frequency electromagnetic radiation for the cooking thereof, the improvement comprising: emitting means in said chamber for emitting infrared radiation in response to said electromagnetic radiation, said emitting means including a heat-resistant, electrically nonconductive plate and converting means formed on a surface of said plate for converting such electromagnetic radiation to infrared radiation, said converting means being an electrically conductive thin film, said emitting means acting upon a foodstuff contained in said chamber to brown the outer surfaces thereof.

2. An electronic range as defined in claim **1** wherein said converting means comprises a thin film of tin oxide formed on said surface of said plate, said film having a thickness of about 5 microns.

3. An electronic range as defined in claim **1** wherein said converting means comprises: a quantity of carbon fibre fixed on said surface of said plate.

4. An electronic range as defined in claim **1** wherein said converting means comprises: a layer of silicon carbide fixed on said surface of said plate.

5. A method of browning the surface of a foodstuff in an electronic range having a chamber in which the foodstuff is subjected to high frequency electromagnetic radiation for the cooking thereof comprising: the steps of providing a container having a thin film of tin oxide formed on at least one surface thereof for emitting infrared radiation in response to electromagnetic radiation in said chamber; placing the foodstuff in said container in contact with said container; and subjecting said foodstuff and said container to said high frequency radiation whereby said foodstuff is cooked by said high frequency radiation and the outer surface thereof is browned by the infrared radiation converted by said tin oxide film from said high frequency radiation.

6. The apparatus as defined in claim **2** wherein said plate is a crystalline glass.

7. Apparatus for converting high-frequency electromagnetic energy into heat energy in an electronic range for browning the outer surface of a foodstuff subjected to such high-frequency radiation for the cooking thereof comprising:

a container for the foodstuff, said container having a heat resistant, electrically insulating base material, and a thin film of tin oxide formed on said base material on at least one surface thereof, said container adapted to support the foodstuff whereby a foodstuff contacting said container is browned by said heat energy while the interior of such foodstuff is cooked by said high-frequency electromagnetic radiation.

8. In an electronic range having a chamber in which a foodstuff is subjected to high frequency electromagnetic radiation for the cooking thereof, the improvement comprising: a heat resistant, electrically nonconductive plate and an electrically conductive thin film of a material absorptive of said radiation applied to a surface of the plate for absorbing such electromagnetic radiation and converting it into heat energy the energy converted by said film resulting solely from said radiation for acting upon a foodstuff contained within said chamber to brown the outer surface thereof.

9. The improvement as set forth in claim **8,** wherein said thin film is tin oxide.

10. The improvement as set forth in claim **9,** wherein said thin film has a thickness of about 5 microns.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,783,220 Dated January 1, 1974

Inventor(s) Hiroshi Tanizaki

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 31;
Change "5 microns" to --0.5 microns--;

Column 6, line 7;
Change "5 microns" to --0.5 microns--.

Signed and sealed this 10th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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(5/69)

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