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Muller et al.

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[54] **MICROWAVE TUNNEL-OVENS**

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[51] **Int. Cl.²** **H05B 9/06**

[58] **Field of Search** ..... 219/10.55 A, 10.55 R, 10.55 D, 219/10.55 E, 10.55 F; 174/35 R, 35 MS

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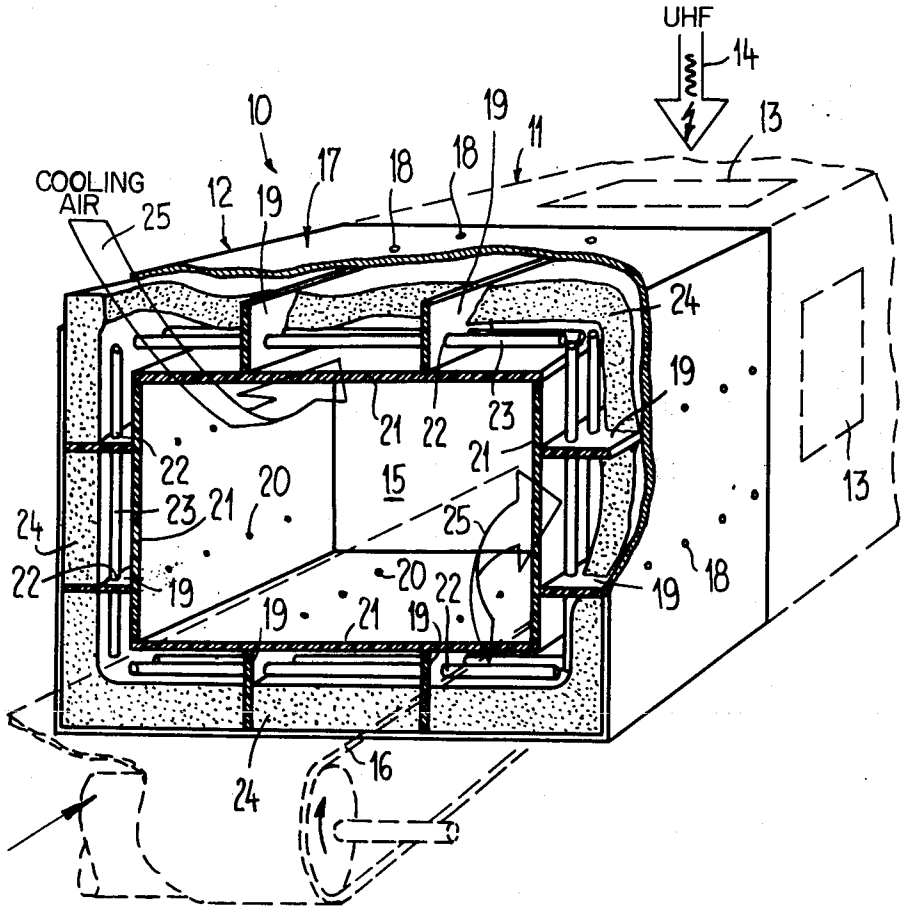
[57] **ABSTRACT**

This invention relates to microwave tunnel ovens of the kind having absorption sections enclosed by a metal casing which form continuations of a central passage of said oven at both the inlet and outlet ends. The invention consists in that said absorption sections contain a plurality of load members, each of which is made of a microwave-absorbent material and is arranged between said casing and said central opening the said load members being spaced from one another. These load members may be individual ferrite rods or tubes or may consist of individual portions of a plastics material helical tube containing a liquid and arranged around the central passage.

8 Claims, 2 Drawing Figures



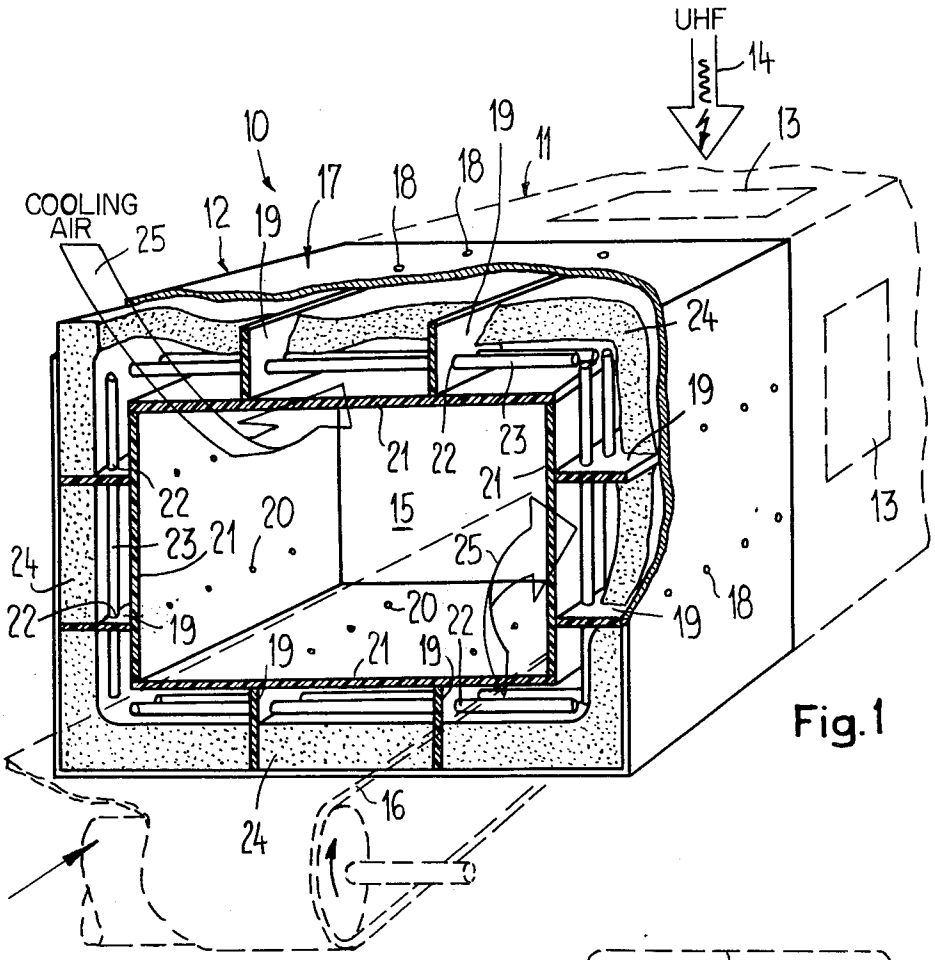

UHF
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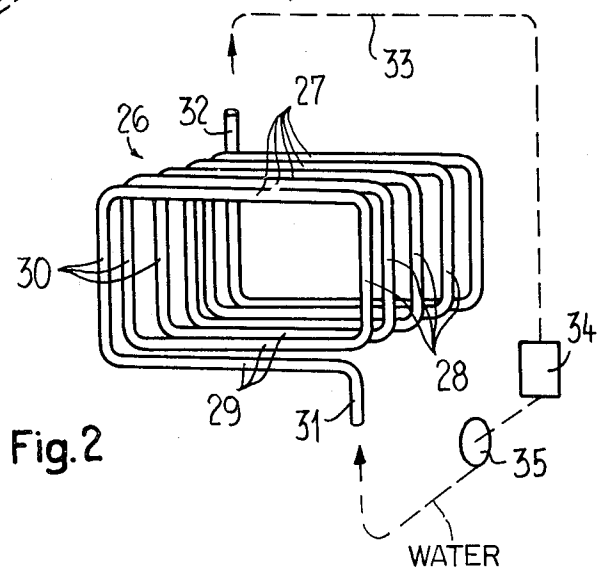
Fig.1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WATER

Fig.2

MICROWAVE TUNNEL-OVENS

BACKGROUND OF THE INVENTION

The present invention relates to microwave tunnel-ovens of the kind having microwave absorption sections enclosed by a metal casing which form continuations of a central passage of said oven at both the inlet and outlet ends. Hereinafter such ovens will be referred to as "of the kind described".

Recently microwave ovens have acquired a particular importance in connection with the heating of precooked food or the cooking of raw food due to the fact that the time they take to cook or heat is orders of magnitude less than the time required with conventional methods of heating or cooking where the direct application of thermal energy is employed.

On the other hand, microwaves are a powerful form of electromagnetic radiation which has no difficulty in passing through diclectrics and heat insulation and can even heat up people, since they are living creatures containing liquid.

As far as ordinary microwave ovens which resemble conventional ovens are concerned there are no problems in confining the microwave field to the interior of the oven space since an oven of this type is capable of being enclosed on all sides by a reflective shield which, because of its reflective nature, is impenetrable to radiation. At the same time relatively simple means can be used to ensure that the source of radiation, usually a magnetron, remains switched off while the oven door is open.

This is not true of tunnel-ovens since this type of oven remains open at both the inlet and outlet ends even while in operation. At their inlets and outlets known microwave tunnel-ovens of the kind described have absorption sections which consist in essence of a water jacket formed by a twin-walled tube, this jacket forming a continuation of the tunnel through the oven of some considerable length. As water is known to be capable of absorbing microwaves and heating up, that is to say it forms a load in the microwave field which consumes energy, it was possible by using water jackets of this type to reduce the strength of any microwave field which could still be detected outside the oven to an acceptable level, despite the open-ended tunnel, the level in question being between approximately 1 and 5 mW/cm^2 depending on local government regulations. This of course called for a considerable length of water-jacket, which increased the overall length of the oven. As a result, manufacturing, purchase, operating and maintenance costs rose to such an extent that, for reasons of expense and available space, the idea of tunnel ovens had hitherto to be abandoned in many applications for which they would have been ideally suited (e.g. large catering establishments, canteens, hospitals.

Even fitting parting bead-curtains made of known microwave-absorbent materials in the inlet and outlet openings did not make it possible to shorten the length of the construction decisively, unless further safety precautions of other types were taken also.

It is an object of the invention therefore to provide a microwave tunnel-oven of the kind described in which the effectiveness with which the microwaves are absorbed is increased several fold with the result that, although the maximum acceptable leakage field level is not exceeded, it is still possible to reduce the overall length of the oven to a size not achieved hitherto. Other

objects and advantages will become apparent in what is to follow.

SUMMARY OF THE INVENTION

The invention consists in that a microwave tunnel-oven of the kind described includes a plurality of load members made of a material which is absorbent to microwaves which load members are arranged between the casing and the central passage in the absorption section, these members being arranged at a distance from one another.

In this way the length of the absorption section in the proposed microwave oven is reduced to a minimum.

In a preferred embodiment the load members may be individual ferrite rods or tubes which may be arranged at a distance from one another transversely to the central passage. In this case satisfactory results can be achieved even with only one row of ferrite rods or tubes arranged in each of the side walls, floor and roof of the shielding.

it is also possible for the load members to be formed by the individual turns of a plastics tube containing a liquid, e.g. water which forms a spiral around the central passage.

In the case of the embodiment which employs ferrite rods or tubes, means are preferably provided to cool these, whereas in the case of the embodiment having a plastics tube which forms a spiral around the central passage there is no need for any special cooling once the liquid in the tube is caused to circulate.

DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show embodiments thereof by way of example and in which:

FIG. **1** shows a simplified, perspective view of the inlet end of a first embodiment of the microwave tunnel-oven in which parts of the shielding at the inlet end are broken away, and

FIG. **2** shows a modification constituting a embodiment with different load members from those shown in the embodiment of FIG. **1.**

SPECIFIC DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, a microwave tunnel-oven marked **10** in FIG. **1** has an oven section proper **11** which is subject to radiation and which is preceded at the inlet end by an absorption section **12.** At the outlet end, oven section **11** is followed by a section (not shown) similar to absorption section **12.** As FIG. **1** shows, in a purely schematic fashion, oven section **11** has one or more UHF excitation apertures **13** which are used to connect up a wave-guide leading to a magnetron. The wave guide and magnetron are not shown since per se they form no part of the invention and are moreover so well known in the art as not to require illustration. The microwave radiation enters the central passage of the oven shown at **15,** through the openings **13,** as indicated by arrow **14.** The articles to be heated in the oven **10** are transported through it by any suitable means shown for example as a conveyor belt **16,** which is therefore only shown diagrammatically, only the top run of the belt **16** passing through the central passage **15.**

The absorption section **12** is delimited on the outside by a casing **17** of polished sheet-metal which is closed off at the inlet end by a screen (not shown) which leaves the central passage **15** free. On the inside, the roof, side-walls and floor of the casing **17** each have secured to them, by means of screws **18**, two longitudinally extending supporting ribs **19**, to the inner longitudinal faces of which is secured, by means of further screws **20**, the inner lining, which consists of plates **21**. Both the supporting ribs **19** and the plates **21** are made from a dielectric material such as polytetrafluorethylene, so that the material in question will not prevent leakage radiation from reaching the space between the plates **21** and the casing **17**. Each of the supporting ribs **19** contains a row of holes **22** each of which is used, as shown, to hold a load member **23** in the form of a ferrite rod or tube. This results in the ferrite rods being arranged in a grid-like structure which is mounted at a distance from the plates **21** and from the inside face of the casing **17**. The load members **23** are also arranged at a distance from one another. The gap between the load members **23** and the inside face of the casing is filled with a layer **24** of a heat-insulating material such as an asbestos, fibreglass or mineral wool mat. In this way there is created between the plates **21** and the structure formed by the rods **23** an open gap through which a flow of cooling air is passed, as shown by arrows **25**. It would seem to be unnecessary to describe at this point the means used to produce this flow of cooling air.

The high efficiency of the shielding described may be attributed to the fact that, when microwave radiation exists, the strength of the microwave field is reduced downstream of each of the load members **23**. The main part of the shielding action occurs as a result of the energy being absorbed in the ferrite rods and tubes and then in the water jacket.

It is, of course, also possible for a plurality of layers of ferrite rods to be arranged in the absorption section but the arrangement shown has proved adequate. In an actual prototype, ferrite rods of 10mm diameter were used at a distance of 10mm from one another. The distance between the ferrite rods and the inner face of the casing **17** was 10mm, and the layer of asbestos **24** was of a similar thickness. The distance between the rods and the outer face of the plates **21** was 4mm. With this arrangement it has been shown that, when the oven section **11** is used as a continuous-flow heater for food, leakage radiation from it is adequately absorbed when the absorption section **12** is 40cm in length. It is important for the load members **23** to be spaced away from the inside wall of the casing **17** so that the field originating from the load members which counteracts the leakage field can be propagated practically without obstruction. Less critical is the gap between the load members and the outer face of the plates **21** and this may as small as desired provided that it is still possible for a stream of cooling air to flow through it.

In FIG. **2** is shown a squarc-cornered, spirally wound plastics tube **26** which may be used in the absorption section **12** shown in FIG. **1** in place of the load members **23**. In this case the individual segments **27, 28, 29** and **30** of the tube form the individual load members. The plastics tube **26** is filled with water and its inlet **31** and outlet **32** are connected to a piping circuit **33** (shown by a broken line) in which are inserted a circulating pump **35** and a cooler **34**. The plastics tube **26** could also be connected to the main water-supply. In the case of the embodiment of the load members shown in FIG. **2**, segments **27** to **30** could be arranged to lie directly against the plates **21** forming the lining and with this arrangement it is not then necessary for the heat due to energy loss to be removed in any special way.

It is also conceivable for provision to be made to combine the load members in FIGS. **1** and **2** by having the segments of a water-filled spiral plastics tube lie directly against the plates **21** forming the lining and by arranging ferrite rods at a distance from one another outside the tube.

We claim:

1. In a microwave tunnel-oven having absorption sections enclosed by a metal casisng forming continuations of a central passage of said oven at both the inlet and outlet ends of said oven, the improvement comprising said absorption sections including a plurality of individual elongated load members of a ferrite material for absorbing microwaves, said plurality of ferrite load members being arranged between said casing and said continuations of said central passage at a distance next to one another in spaced relationship transversely to said continuations of said central passage.

2. A tunnel-oven according to claim **1**, including a lining surrounding said continuations of said central passage, which lining is composed of a dielectric material, and wherein said load members are arranged at a distance from said lining between said casing and said lining.

3. A tunnel-oven according to claim **2**, wherein a layer of heat insulating material is arranged between said ferrite members and said metal casing, the spacing between said lining and said ferrite members being sufficient to allow a flow of cooling air to pass through said spacing.

4. A tunnel-oven according to claim **3**, wherein the thickness of said layer of heat-insulating material is between two and three times the width of the spacing between said ferrite members and said lining.

5. A tunnel-oven according to claim **1**, wherein said ferrite members are spaced apart by a distance approximately corresponding to their diameter.

6. A tunnel-oven according to claim **1**, wherein additional load members are formed by individual portions of the turns of a tube which forms a spiral around said continuations of said central passage and is arranged to contain a liquid.

7. A tunnel-oven according to claim **6**, wherein one end of said tube is connected to a source of pressurised cooling liquid.

8. A tunnel-oven according to claim **6**, including a lining of a dielectric material surrounding said continuations of said central passage, and wherein said additional load members lie directly against said lining and said plurality of ferrite load members are arranged between said additional load members and said casing.

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