EUROPEAN QUALIFYING EXAMINATION 1993

PAPER A
ELECTRICITY / MECHANICS

This paper comprises:

INSTRUCTIONS TO CANDIDATES

You are to assume that you have received the annexed letter from your client including a description of an invention for which he wishes you to obtain a European patent together with references to the most pertinent prior art known to your client.

You should accept the facts given in the paper and base your answers upon such facts. Whether and to what extent these facts are used is your responsibility.

You should not use any special knowledge you may have of the subject-matter of the invention, but are to assume that the prior art given is in fact exhaustive.

Your task is to draft an independent claim (or claims) offering the applicant the broadest protection possible while at the same time having a good chance of succeeding before the EPO. In drafting your claim(s) you should bear in mind the need for inventive step over the prior art indicated, the requirements of the Convention, in particular as to the form of claims, and the recommendations made in the Guidelines for Examination in the EPO. Dependent claims should also be drafted so as to enable you to fall back upon them should the independent claim(s) fail and should be kept to a reasonable number.

You are also expected to draft an introduction, i.e. that part of the description which precedes the examples or the explanation of the drawings. The introduction should be sufficient to provide support for the independent claim(s). In particular, you should consider the advisability of mentioning advantages of the invention in the introduction.

You are expected to draft claims and an introduction for one European patent application only. This application should meet the requirements of the Convention as to unity. If you would in practise seek to protect further inventions by filing one or more separate applications, you should, in a note, clearly identify the subject-matter of the independent claim of such separate application(s). However, it is not necessary to draft the wording of the independent claim for the or each separate application.

In addition to your chosen solution, you may – but this is not mandatory – give, in a note, the reasons for your choice of solution, for example, why you selected a particular form of claim, a particular feature for an independent claim, a particular piece of prior art as starting point or why you rejected or preferred some piece of prior art. Any such note should however be brief.

It is assumed that you have studied the examination paper in the language in which you have given your answer. If this is not so, please indicate on the front page of your answer in which language you have studied the examination paper. This always applies to candidates who – after having filed such a request when enrolling for the examination – give their answer in a language other than German, English or French.

Client's Letter

We are a firm producing and selling kitchen appliances, in particular microwave cooking appliances. In order to allow a better understanding of our invention, a few remarks in general about microwave cooking appliances, termed microwave ovens in what follows, will first be made.

In a conventional oven, food is heated by placing it in a heated cavity of the oven.

Microwave ovens function in a different manner. The oven cavity is not directly heated. Instead, electromagnetic radiation is caused to enter the food to be heated. The molecules of water and other substances present in the food to be heated absorb this radiation and transform it into heat. For this purpose the wavelength of the radiation has to be very short.

Very short wavelength radiation has a very high frequency. Hence an essential component of a microwave oven is a high frequency radiation generator, e.g. a so-called magnetron. A typical frequency value is about 2 500 MHz ($2,5 \times 10^9$ cycles per second).

Such a magnetron is a high technology device having relatively large dimensions so that it cannot be placed in the oven cavity. It could, in principle, be placed in the direct vicinity of one of the walls of the oven cavity, directly radiating into the oven cavity, but this would result in an appliance of cumbersome size and shape. The magnetron is therefore usually located in a separate compartment provided beside the oven cavity and behind the control panel of the microwave oven.

There is thus a need to convey the microwave radiation produced the magnetron to the oven cavity. To achieve this, several microwave conveying means are known, the most common one being a so-called waveguide which is a hollow element of generally cylindrical shape having a rectangular or circular cross-section. A waveguide is made of electrically conductive material and allows microwaves to propagate inside it, in part by direct transmission and in part by single or multiple reflections on its inner walls.

The microwaves generated by the magnetron are radiated into the waveguide by means of a radiating element extending into the waveguide at one end and functioning as an antenna. This element is the so-called (transmitting) coupling probe. A second (receiving) coupling probe is used in the same way to couple out the microwaves at the other end of the waveguide.

From this other end of the waveguide, the microwaves are radiated into the oven cavity by means of an electrically conductive antenna extending into the oven cavity. This antenna is directly connected to the coupling probe extracting the microwaves out of the waveguide.

The location at which the microwaves are introduced into the oven cavity is of minor importance as long as it is ensured that the microwaves reach the food to be heated in some way or other. In other words, the location of entry can be provided in any wall (top, bottom and sides) of the oven cavity. It should be noted that the walls of a microwave oven cavity are made of electrically conductive material (being non-transparent and reflective to microwaves) and that single and multiple reflections of microwaves occur within the oven cavity.

A problem associated with microwave ovens is that the spatial distribution of the microwave energy in the oven cavity tends to [be] non-uniform. As a result, "hot spots" and "cold spots" are produced at different locations in the oven cavity. This can lead to unsatisfactory cooking results because some portions of the food may be completely cooked while others are barely warmed. This problem becomes more severe with foods of low thermal conductivity.

One explanation for this non-uniform distribution of the microwave energy is that, due to reflections and superpositions of waves within the oven cavity, standing wave patterns are set up. Consequently, microwave energy varies greatly with position within the oven cavity.

These patterns are moreover dependent upon the reflectivity, type, shape and quantity of the food which is placed in the oven cavity.

In order to obtain a uniform cooking of the food, it is therefore desirable to alter the relative locations of the above-mentioned wave patterns and the food as a function of time.

A number of different approaches to achieving this have been proposed. The one most widely known is the use of a rotating plate which moves the food through spots of high and low microwave energy in the wave patterns. The averaging over time of the heating of the food results in a relatively uniform cooking. The results are however not quite satisfactory since, on the one hand, the wave patterns remain dependent upon the above characteristics of the food and, on the other hand, problems might be caused by food touching or hitting the side walls of the oven cavity as it rotates. In the worst case this could even prevent rotation of the food.

Another approach uses a rotational antenna within the oven cavity which generates a time varying wave pattern in the oven cavity. An example of such a microwave oven, which is being sold successfully by our firm, was disclosed three years ago in Document I.

The oven of Document I uses a fan which has two distinct functions: in the conventional cooking mode of the oven (which plays no role in the present context) the fan, which is provided with two fan-blades, actually acts as a fan for stirring the air in the oven cavity; in the microwave cooking mode the fan acts as a rotational antenna. The rotational antenna is hence essentially T-shaped and is rotated about the axis of symmetry of the "T". The rotational antenna generates a rotating microwave field in the oven cavity while the food remains stationary.

Our invention is concerned with the above-described "rotational antenna approach". Although the results achieved in the microwave oven of Document I are quite satisfactory, some disadvantages remain. As in any microwave oven cavity, reflections of the microwaves occur inside it. Although - due to the rotation of the antenna - the field is varied as a function of time, a relatively high percentage of the microwave energy does not directly reach the food to be heated, the single or multiple reflections on the side walls causing losses in the reflected waves, which results in a decreased efficiency of the heating process.

We have made attempts to improve the efficiency of the heating process by using a directional rotational antenna as described in Document II (which we published in a microwave journal last year) in the cooking appliance of Document I. This antenna radiates the microwaves in a predominant direction, i.e. mainly towards the food to be heated.

However, the results were not very satisfactory, since again the reflections on the side walls caused losses of microwave energy.

It was hence our intention to improve further the efficiency of the oven and also the microwave energy distribution within the oven cavity. The oven should moreover be particularly suitable for the use of the antenna of Document II; the use of other antennas should however not be excluded.

We have achieved this objective by means of a special design of the region of the wall from which the microwaves are radiated into the oven cavity by means of the rotational antenna. This design allows a concentration of the microwave energy towards the centre of the oven cavity. This particular design is described later in detail. It helps to keep the radiation away from the side walls of the oven cavity. As in any microwave oven, the location of entry of the microwaves into the oven cavity can be provided in any wall of the oven cavity.

The particular design of the wall mentioned above renders possible a special air flow within the microwave oven. This air flow is also described later in detail and permits the multiple use of the air in the microwave oven.

This design allows - among other advantages and properties - the rotation of the antenna by means of the air flow in the oven, as suggested by Document II.

The invention will now be described with reference to the appended drawings, where:

Fig. 1 is a front view of a microwave oven of the present invention;

Fig. 2 is a cross-sectional view of the oven taken along the line 2-2 of Fig. 1; and

Fig. 3 is a cross-sectional view taken along the line 3-3 of Fig. 2.

Fig. 1, which illustrates a front view of a microwave cooking appliance of the present invention, shows the microwave oven 10 having a housing 12, which houses the internal components of the oven 10. The oven cavity 14, as illustrated in Fig. 3, has five conductive metallic sides, of which a top wall 14a, a left side wall 14c (Fig. 2), a right side wall 14d, and a rear wall 14e are shown. A door 16 pivotably hinged at the bottom forms a front wall of the oven cavity. The door 16 is provided with a door gasket to prevent any leakage of microwave energy between the walls 14a, c and d and the outer perimeter of the door 16.

The door 16 is provided with a see-through window and a handle 16a. The window is provided with a conventional microwave energy reflecting structure. Food 17 to be cooked is shown in Fig. 1. A control panel 18 features a plurality of control keys connected to suitable control circuitry for setting cooking times, temperatures and power levels. The control circuitry is connected to a microwave generator such as a magnetron 28. An exhaust vent 20 is provided in the upper front right corner of the oven 10 to allow cooking vapours and moisture to be expelled from the oven cavity 14.

Reference will now be made to Figs. 2 and 3. A dome-shaped reflecting element 22 having essentially the form of a truncated cone is provided in the top wall 14a of the oven cavity. The dome has a periphery 22a of a large diameter at the base of the cone, a curved sloping section 22b including a planar rectangular transition section 24 to be described later and a periphery 22c of a small diameter where the cone is truncated. The dome is provided with a planar top wall 22d parallel to the top wall 14a of the oven cavity.

The rectangular transition section 24 included in the sloping section 22b of the dome includes a straight lower and a straight upper transition junction 24a and 24b respectively. The transition section 24 forms part of a waveguide 26 of generally rectangular cross-section and constitutes a transition between a length of waveguide having a larger cross-sectional area and a length of waveguide having a smaller cross-sectional area.

The waveguide 26 has side walls 26b and 26c, a plane top wall 26a and end walls 26e and 26d. The side and end walls of the waveguide are mounted by means of flanges 30 to the top wall 14a of the oven cavity, to the sloping section 22b and to the top wall 22d of the dome.

A coupling probe 28a connected to the magnetron 28 extends into the waveguide 26 at its one end and couples microwave energy into the waveguide. A directional rotational antenna 32 known per se from the above-mentioned Document II can be seen in Fig. 3 and is also shown in dashed lines in Fig. 2. A microwave-transparent grease shield 46 separates the antenna 32 from the portion of the oven cavity 14 in which the food to be heated is placed. The antenna 32 is connected to a coupling probe 34 which also constitutes a rotational axle of the antenna and extends into the waveguide 26. Microwave energy is thus transmitted from the magnetron 28 via the coupling probe 28a into the waveguide 26, and from there via the coupling probe 34 to the rotational antenna 32 from which it is radiated into the oven cavity 14.

The transition section 24 of the waveguide 26 serves to optimi[ze] the transfer of microwave energy from the magnetron 28 to the rotational antenna 32, such a measure being common in microwave appliances.

It should be noted that the provision of the waveguide 26 directly along the top wall 14a of the oven cavity, the sloping section 22b and the top wall 22d of the dome is particularly advantageous since in this way the manufacture of the oven is considerably simplified. During manufacture the upper portion of the waveguide, which consists of the top wall 26a, the side walls 26b and c and the end walls 26d and e, is spot-welded to the top wall 14a of the oven cavity and to the dome by means of the flanges 30 provided along the side and end walls 26b to e. Thus only two punched sheet-metal components are needed to obtain the essential parts of the microwave conveying system of the oven: the first one comprises the top wall 14a of the oven cavity including the dome 22 and the second one comprises the upper portion of the waveguide mentioned above.

The coupling probe 34 supplying microwave energy to the antenna 32 is mounted in a microwave-transparent dielectric bushing 36 located in an opening 22e in the top wall 22d of the dome. The X-shaped base element of the antenna 32 (see Document II) is provided with small, angled turbine blades 33 (see Fig. 3) which are rotated by a forced air flow which will be explained later.

The shape of the dome described above provides the following advantages as compared with the oven disclosed in Document I: the dome uniformly reflects that portion of the microwave energy which is not directly radiated from the antenna towards the food to be heated. This portion of the microwave energy, which also exists for directional antennas (which ought to predominantly radiate directly towards the food to be heated), is hence efficiently concentrated towards a centre region of the oven cavity. The dome also returns the microwaves reflected by the food to be heated back towards an area in the centre of the oven cavity and thus back again towards the food to be heated. The resulting rotati[ng] microwave field is thus not dependent upon the side walls of the oven cavity 14 for the distribution of microwave energy. It may therefore be said that the dome concentrates the microwave energy on the food to be heated by keeping the radiation away from the side walls of the oven cavity. Due to the concentration of the microwave energy towards the centre of the oven cavity, a very efficient heating of the food, in particular when it is heavy and bulky, is obtained. Such food in particular requires a higher concentration of microwave energy in the centre than in the peripheral regions of the food.

Moreover, the symmetry of the dome, which is essentially not disturbed by the planar transition section 24, ensures uniform radiation conditions for the antenna during rotation.

Turning to the geometry of the dome, it should be appreciated that the dome can basically be designed in a manner analogous to an optical reflector. The angle of inclination α (see Fig. 3) of the sloping section of the dome therefore mainly depends upon the geometry of the oven cavity and upon the position of the rotational antenna within the oven cavity. A useful range of angles of inclination α for typical cavity geometries (e.g. such as that shown in Figs. 1 and 2) is about 25 to 40 degrees.

The air flow mentioned above will now be described. A blower 40 shown schematically in Fig. 2 draws air through a plurality of holes (not shown) in the bottom of the oven 10. The air is then blown over the inside of the control panel 18 and heat-dissipating fins of the magnetron 28 in order to cool them.

All of the air is then forced up through small openings 29 in the top wall 14a of the oven cavity. The air is thus introduced into the waveguide 26. The provision of the small openings 29 in the waveguide does not have any influence upon the propagation of the microwaves therein. The air leaves the waveguide downwardly through holes 22f around the bushing 36 and thus drives the antenna 32 by means of the angled turbine blades 33. Instead of being provided directly with turbine blades, the antenna 32 can support a microwave-transparent dielectric disc carrying the necessary turbine blades for driving the antenna by means of the air flow.

The air then flows out of the space between the grease shield 46 and the top wall 14a through openings 47 (Fig. 3) in the grease shield and flows into the oven cavity 14 from where it expels cooking vapours. The air finally leaves the oven cavity via openings 14f in the side wall 14d (Fig. 2) and an air duct 19 which directs it to the exhaust vent 20.

The air flow has only been described schematically, since many variants can be provided. It permits only one blower to be used to cool the control panel 18 and the magnetron 28, to drive the antenna 32 and finally to expel cooking vapours from the oven cavity 14.

It should be noted that the transition section 24 has the additional advantage of reducing the cross-sectional area of the air flow in the waveguide. This results, in combination with suitable diameters of the holes 22f, in a considerable increase in the air speed which ensures a reliable rotation of the antenna 32.

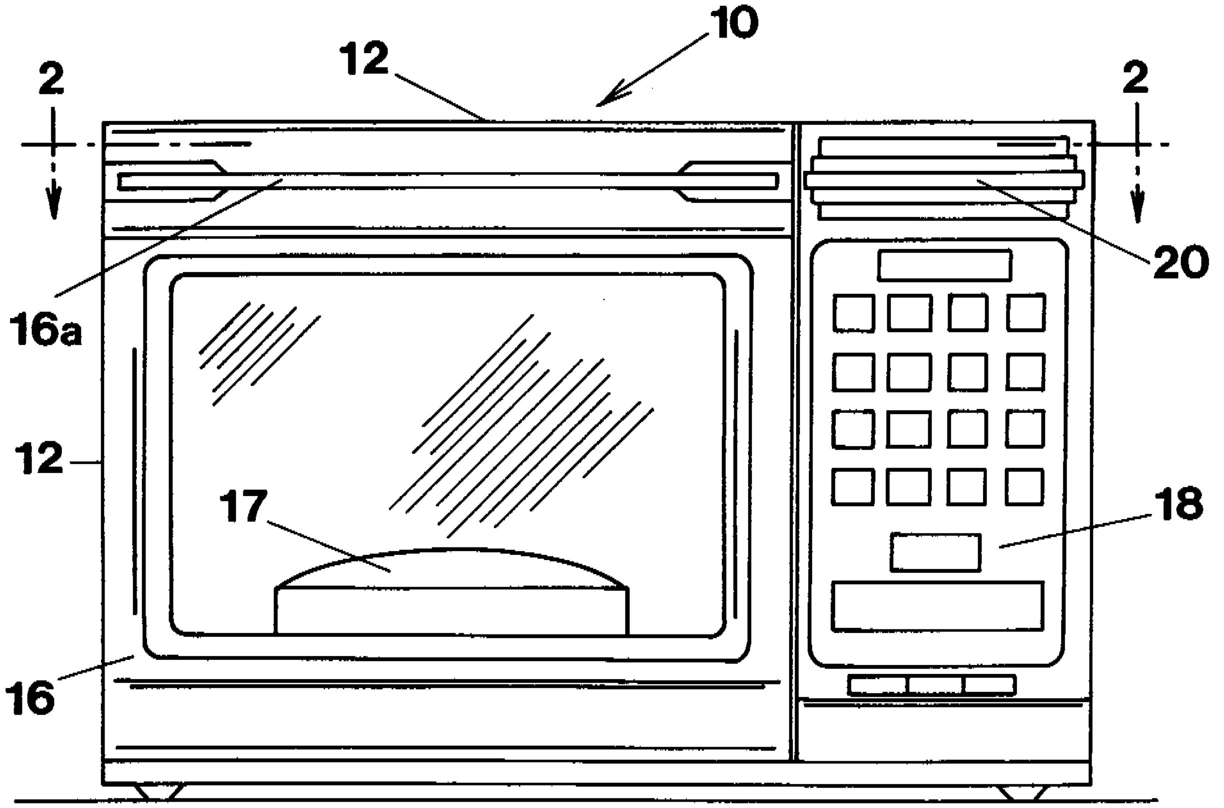
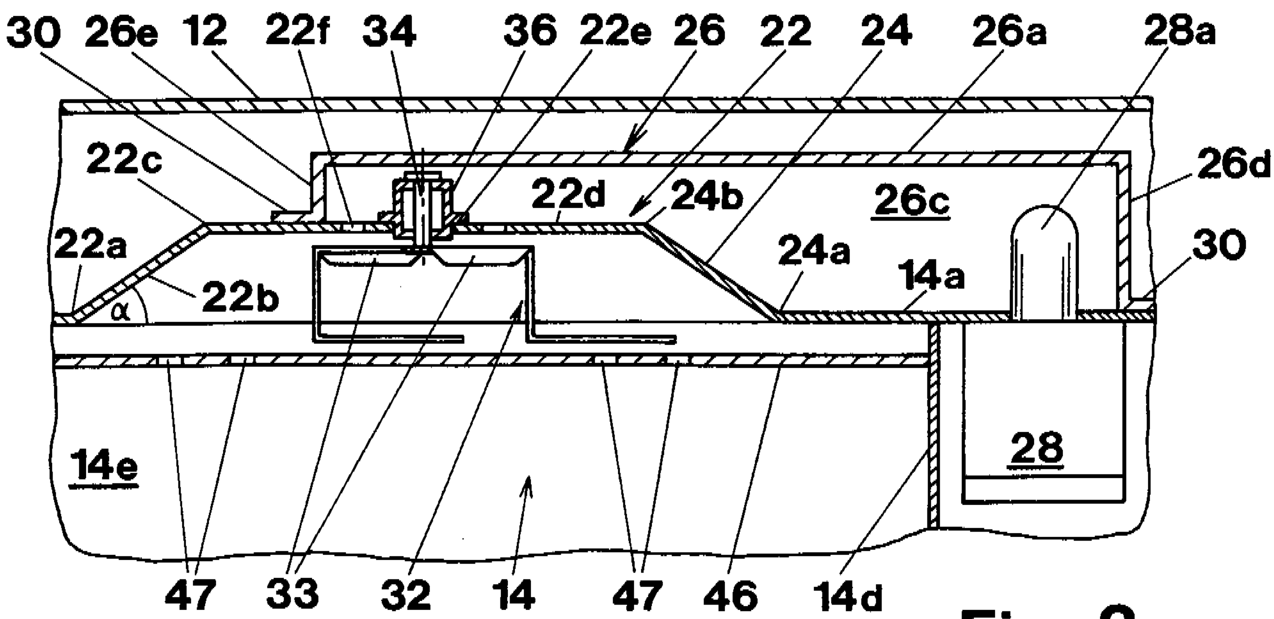

10
12
2
2
20
16a
12
17
18
16

Fig. 1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22f
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36
22e
26
22
24
26a
28a
22c
22d
24b
26c
26d
22a
24a
14a
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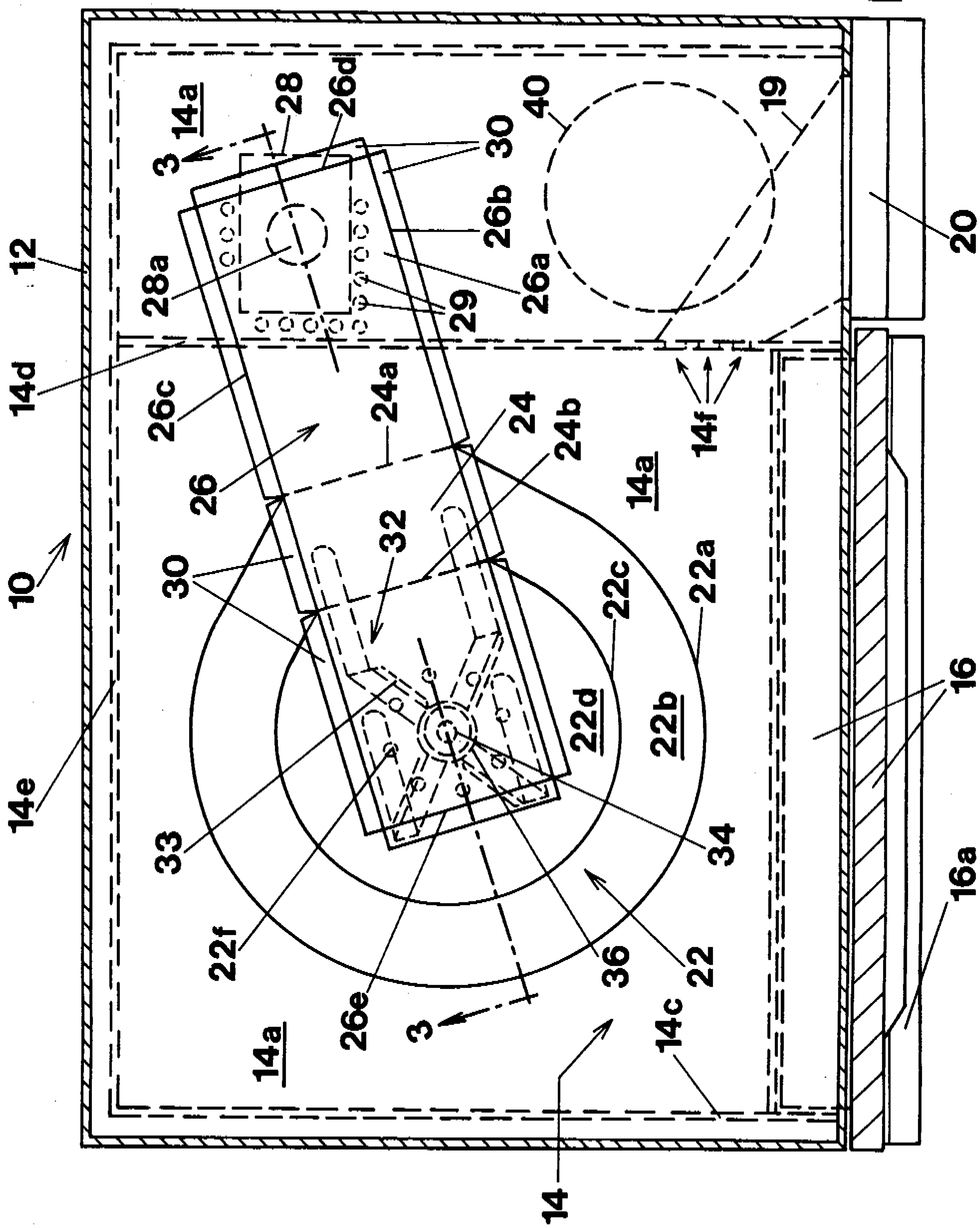
28
47
33
32
14
47
46
14d

Fig. 3

Fig. 2


3
14a
28
26d
30
40
19
20
12
28a
26b
26a
29
14d
24a
26c
24
24b
14f
14a
26
32
30
22a
22c
10
22d
22b
16
14e
33
34
16a
22f
26e
36
22
3
14a
14c
14

DOCUMENT I (State of the Art)

The invention relates to a combination convection and microwave oven in which cooking can be carried out by means of conventional electric heating or by means of microwaves. In the microwave cooking mode the problem arises of guaranteeing a homogeneous distribution of the microwave field averaged over time. One way to solve this problem without moving the food to be cooked is to use a rotational antenna radiating microwaves into the oven cavity.

In order to allow a more homogenous heat distribution in the oven cavity in the conventional electric heating mode, the oven has a motor-driven fan which stirs the air within the oven cavity.

The invention solves the problem of providing and suitably positioning all the elements necessary for proper operation of the oven in both operating modes. The invention is illustrated by means of the drawing which is a schematic cross-sectional view of the oven in a vertical plane.

The oven comprises a housing 19 enclosing an oven cavity 17. The oven cavity 17 is surrounded by an insulating jacket 7 and has a door 18 with a handle 16. The lower portion of the housing 19 contains a microwave generator, e.g. a magnetron 3, and a mains supply transformer 4 therefor. A fan 2 takes in cooling air for the magnetron 3 from an inlet 1.

The microwaves generated by the magnetron 3 are coupled by means of a coupling probe 3a into a conventional waveguide 5 of rectangular cross-section. The complete waveguide is secured to the rear wall of the oven cavity 17 and extends to about half the height thereof. A metallic two-blade fan 11 having a shaft 12 is mounted inside the oven cavity . The two blades and the shaft also serve as an essentially T-shaped rotational antenna. The part of the shaft 12 which extends into the waveguide 5 serves as a coupling probe and couples the microwaves out of the waveguide into the antenna. The shaft 12 is supported in a dielectric bearing (not shown) extending through a wall of the waveguide 5 and the rear wall of the oven cavity 17.

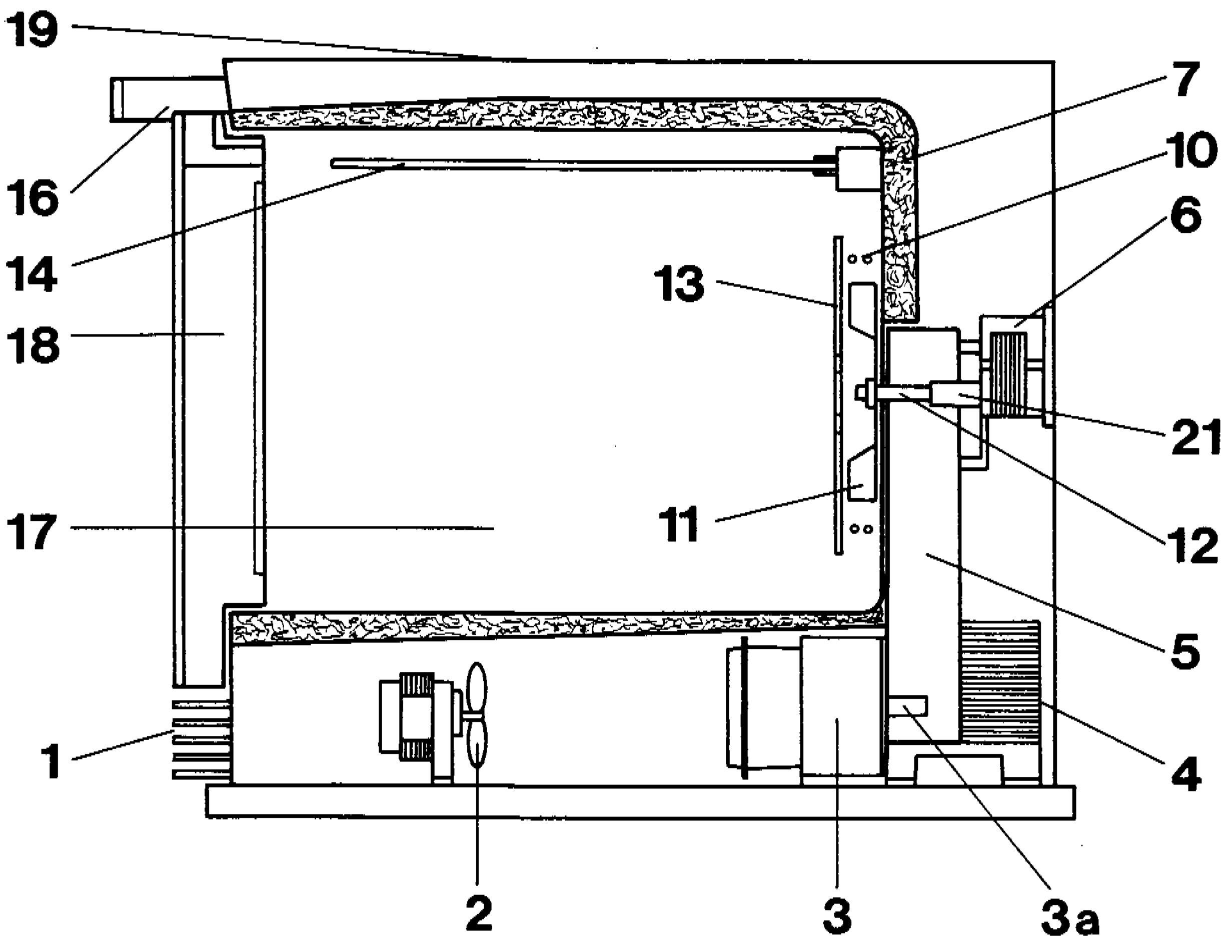
The antenna is driven by means of an electric motor 6 via a shaft extension 21 made of an insulating material transparent to microwaves. The reason for this is that, in order to serve as a coupling probe, the shaft 12 must not extend completely across the waveguide 5. Within the oven cavity 17 the fan 11 is surrounded by conventional electric heater elements 10 (shown schematically) and an electric grill 14 may additionally be mounted in the upper portion of the cavity 17.

In front of the fan 11 and the heater elements 10 there is a protective panel 13 made of heat-resistant material transparent to microwaves, e.g. a vitreous ceramic material. The protective panel 13 has openings permitting air to be circulated within the cavity 17 by the action of the fan 11. The air is drawn behind the panel 13 through the openings and expelled radially.

The motor 6 can operate at two different speeds. When driven at low speed, the fan 11 and the shaft 12 function as a rotational antenna transmitting the microwave energy from the waveguide 5 into the oven cavity. Due to the rotation of the antenna, the microwave energy is evenly distributed throughout the oven cavity. It is therefore not necessary to provide means for rotating the food to be cooked, such as a rotating plate, in order to obtain a good microwave energy distribution in the oven cavity.

In the conventional electric heating mode (in which the magnetron 3 is switched off and the heater elements 10 are switched on), the fan 11 is driven at high speed so that the oven functions as a hot air convection oven.

Drawing of Document I (State of the Art)



DOCUMENT II (State of the Art)

This document relates to a directional microwave antenna which can be advantageously used in microwave cooking appliances equipped with rotational antennas.

The antenna is shown in Figs. 1 and 2, which are top and side views respectively.

The antenna A is made of a punched sheet of conductive material, such as copper, brass or aluminium and consists of a planar X-shaped base element 1 having four support members 2 (see Fig. 2) perpendicular thereto. Each of the support members 2 carries an antenna element 3.

The base element 1 is provided with an axle 4 about which the antenna A is rotated in an appropriate bearing during use. The axle 4 also serves as a coupling probe by extending into a waveguide (not shown) supplying microwave energy.

The antenna has a directional radiation characteristic. The generated microwave field is substantially planar and extends along the plane of symmetry S of the antenna A of Fig. 1, since the antenna elements 3 are arranged such that undesired field components in directions perpendicular to the axis cancel each other out.

The antenna, in particular the X-shaped base element, can be equipped with means such as turbine blades (either directly or on additional support means) to rotate the antenna by means of an air flow within the oven cavity.

Drawings of Document II (State of the Art)

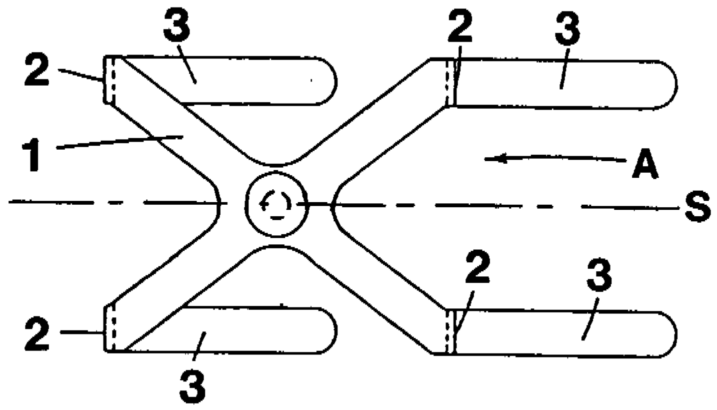


Fig.1

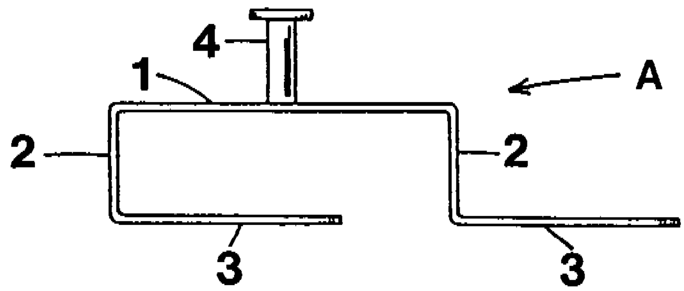


Fig. 2