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(54) **MICROWAVE OVEN**

MIKROWELLENOFEN

FOUR A MICRO-ONDES

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(56) References cited:
WO-A-97/44988 **DE-A- 1 515 149**
DE-U- 8 900 624 **GB-A- 944 993**
GB-A- 1 114 938 **US-A- 2 814 708**
US-A- 3 943 318 **US-A- 3 991 295**

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Description

Field of the Invention

[0001] The present invention relates to a microwave oven and feeding of the same with microwaves.

Technical Background

[0002] Microwave ovens for domestic use and the like are usually made with an essentially rectangularly parallelepipedal cavity. This is due to both manufacturing considerations and a conventional view of what microwave ovens should look like. Although it is possible to a certain extent to calculate which so-called cavity modes are obtained in a rectangularly parallelepipedal cavity, it has proved difficult to achieve a reasonably symmetrical heating pattern in such a cavity, in particular when it is fed sideways. So-called field stirrers or rotating bottom plates for the load are often employed with a view to improving the heating pattern.

[0003] In similar contexts, such as tunnel furnaces for industrial microwave heating, vertical cross-section geometries (across the direction of transportation through the furnace) other than rectangular ones have been used. In this connection, it has been considered that the action of the walls can be interpreted on the analogy of optical reflection, that is, one conceives of being able to obtain optical-geometrical control of the distribution of the microwaves.

[0004] An example of such a configuration of microwave ovens where "microwave reflection" is considered to be employed is disclosed in EP 0 268 379 B1. A microwave oven having sloping corners surfaces between the side walls and the top wall is disclosed by US-A-2814708. DE-A-1515 149 discloses a microwave oven cavity having vertical side walls that do not form corners of 90° between each other.

Objects of the Invention

[0005] An object of the present invention is to make possible an improved heating pattern in a rectangularly parallelepipedal cavity in a microwave oven.

[0006] Another object of the invention is to make possible such an improved heating pattern without employing moving parts, such as field stirrers or rotating bottom plates.

[0007] A further object of the invention is to provide a method which allows improved configuration of a rectangularly parallelepipedal cavity with respect to the resulting heating pattern.

Summary of the Invention

[0008] The above-mentioned objects are achieved by a microwave oven according to claim 1 and a method for microwave feeding of a rectangular parallelepipedal mi-

crowave oven cavity according to claim 8 which exhibit the features stated in the appended claims.

[0009] The basis of the invention is thus that, surprisingly, it has been found that the heating pattern in a rectangularly parallelepipedal oven cavity can be advantageously affected by the arrangement of a non-constant horizontal cross-section in the cavity. In this connection, the cross-section changes concerned do not change the general rectangularly parallelepipedal shape and cannot be compared to wall embossing, rounding of corners, etc. which are conventionally done in order to adjust the rectangularly parallelepipedal dimensions for manufacturing reasons and generally to facilitate the manufacture of the cavity and improve mechanical stability.

[0010] We have found that the approach to reflection described above lacks relevance in the case of smaller cavities of the kind which exist in microwave ovens for domestic use.

[0011] The invention is thus based on the insight that the relative phase and amplitude of the modes in the cavity can be modified favourably in and for heating pattern levelling-out or equalisation by means of well-judged, relatively modest vertical changes to the horizontal cross-section of the cavity. Put another way, by making these kinds of cross-section changes, one can control the mode balance with respect to both relative amplitudes and phase of the modes involved so that a more even heating pattern is achieved.

[0012] We have found that if the cross-section modifications according to the invention are kept relatively small and preferably with a slow vertical change, characterisable cavity volume modes are maintained while the heating pattern is changed. The changes can be observed experimentally, which provides an opportunity for adjustments in order to achieve the best heating pattern.

[0013] In experimental tests, when the cross-section change is varied in small steps, it has been found to be possible to follow the heating pattern changes continuously, which, as will be appreciated, provides very good optimisation conditions.

[0014] According to the invention it is preferable to employ a horizontal cross-section change vertically, which means that the horizontal cross-section decreases upwards at least in the upper part of the cavity. Advantageously, the cross-section change can be achieved by a cavity side wall being made at least partly inward sloping.

[0015] Thus, according to a first aspect of the invention, a method is provided for microwave feeding of a rectangularly parallelepipedal microwave oven cavity, which means that in and for equalisation of the effect of the microwaves in the cavity, the mode balance of the microwave field is affected by the cavity being given, in relation to the horizontal cavity bottom cross-section, at least in the upper part of the cavity an upwardly decreasing horizontal cross-section. In this connection, it is preferred to achieve the decreasing horizontal cross-section by sloping inwards at least the upper part of a cavity side wall. The feeding of microwaves is advantageously done

through an opening in a cavity side wall opposing the inward sloping wall, the microwave feeding preferably taking place along an area closely adjacent to the cavity ceiling.

[0016] Alternatively, it is also possible to feed microwaves through an opening in the cavity ceiling, also in this case suitably extended in a direction parallel to the sloping side wall.

[0017] According to a second aspect of the invention, a method is provided for acting on the heating pattern, which is obtained by means of microwaves fed into an rectangularly parallelepipedal microwave oven cavity, changes to the heating pattern being achieved by a cavity side wall being caused to slope inwards at least in its upper part, so that the cavity has an upwardly decreasing horizontal cross-section in relation to the available bottom cross-section of the cavity. In this connection, it is possible on the basis of a chosen cavity width to vary the horizontal cross-section change by changing the degree and/or extent of the inward slope of the cavity wall and observing the resulting changes to the heating pattern. It will be appreciated that by carrying out such changes of the inward slope of the side wall for a number of different cavity widths, it is possible to determine the cavity width and side wall inward slope combination which provides the best heating pattern.

[0018] In this connection, it should be mentioned that it has been found that the inventive effect on the heating pattern is particularly pronounced for certain cavity widths.

[0019] According to a third aspect of the invention, a microwave oven is provided, comprising a rectangularly parallelepipedal cavity and a microwave source connected thereto for feeding microwaves into the cavity, the cavity, in relation to its available bottom cross-section, having an upwardly decreasing horizontal cross-section at least in the upper part of the cavity. In this connection, the cavity preferably has a side wall, which at least partly slopes inwards in order to provide the desired horizontal cross-section decrease. Advantageously, the inward slope is in the upper part of the side wall, while the lower part of the side wall is vertical and preferably at least 50 mm high. The inward slope of the upper part of the side wall does not need to extend all the way up to the cavity ceiling, rather the side wall can have a short vertical ceiling connection part terminating at the top. Although, preferably, the sloping side wall part is plane, other configurations are also possible. The slope of the side wall is preferably over essentially the whole actual wall width and advantageously over at least about half the wall height.

[0020] For manufacturing reasons, the slope of the side wall can be made within a deep-drawn portion of the side wall, so that the joining with the back wall and the front of the oven can be done with vertical joints. In this case, the slope can advantageously be over about 85% of the total depth of the cavity.

[0021] A microwave oven according to the invention

suitably has a horizontal cross-section which is approximately square. The "depth" is preferably between about 85% and about 120% of the "width". For a microwave oven for conventional domestic use (with a microwave frequency of 2450 MHz) it has been found that the following two dimensionings are particularly advantageous:

1) Horizontal cross-section width at the top between about 315 mm and about 335 mm, preferably about 325 mm. Available bottom cross-section width between about 8 mm and about 15 mm larger.

2) Horizontal cross-section width at the top between about 385 mm and about 410 mm, the available bottom cross-section width being between about 8 mm and about 15 mm larger.

[0022] In both cases, the height of the cavity from the bottom plate or the cavity bottom to the cavity colling is from about 160 mm to about 230 mm.

The invention affords a number of advantages :

An even and essentially coldspot-free heating pattern; Improved symmetry right-left in the heating pattern in a cavity fed from the side, in particular in an oven without moving parts;
A wider oven at the bottom;
A more "space-efficient" oven;
Greater freedom in the choice of cavity dimensions;

A further degree of freedom for configuration adjustments; and
Greater freedom in the choice of the location of the microwave feeding.

[0023] The invention will be described in more detail below by way of embodiments with reference to the accompanying drawings.

Brief Description of the Drawings

[0024]

Fig. 1 is a schematic perspective view of an embodiment of a microwave oven according to the invention.

Fig. 2 schematically shows a vertical cross-section through the middle of the oven in Fig. 1.

Fig. 3 schematically shows a vertical cross-section of the same kind as in Fig. 1 through another embodiment of a microwave oven according to the invention.

Description of Embodiments

[0025] The embodiment of a microwave oven according to the invention illustrated in Figs 1 and 2 comprises an outer casing 1 which is outlined only and an oven cavity 2, which is closed by means of a front door 3. The

cavity 2 is formed by a horizontal cavity bottom 4, a horizontal cavity ceiling 5, a vertical back cavity wall 6, a front vertical wall on the inside of the front door 3 and two cavity side walls 7 and 8. The right side wall 7 in Figs 1 and 2 is vertical and provided with a microwave unit for feeding microwaves into the oven cavity through a slot-shaped, rectangular side wall opening 10, such as will be described in more detail below. The left side wall 8 in Figs 1 and 2 slopes inward somewhat and thus forms an angle of about 3° to vertical. Consequently, the cavity is rectangularly parallelepipedal except for the inward slope of the side wall 8. However, the inward slope is so small that it cannot be considered that there is any essential deviation from the rectangularly parallelepipedal shape, except for the resulting microwave characteristics.

[0026] All the cavity defining wall surfaces in this embodiment are generally plane, although the sloping side wall 8 joins the cavity ceiling at the top with a vertical wall part 11 of a small height.

[0027] It will be appreciated that in the example shown the horizontal cross-section of the oven cavity will gradually decrease upwards by the horizontal cross-section width decreasing upwards from the available bottom width B1 to the ceiling width B2. It will be appreciated that the horizontal cross-section in depth is constant.

[0028] The microwave unit 9 comprises in a manner known per se a magnetron 13 and a waveguide device 14 connected thereto for feeding microwaves into the cavity through the feeder slot 10. As was mentioned above, this slot is usually elongated and rectangular and arranged at the top and in the midpoint on the side wall 7 in the connection area to the cavity ceiling 5.

[0029] As will be seen from Fig. 2, the oven can comprise a microwave-transparent bottom plate 16 for a foodstuff load 17. If desired, this plate can be rotatable. However, it has been found that the oven constructed according to the invention despite the sideways feeding of microwaves gives a heating pattern which is so even that a rotating bottom plate cannot be considered necessary.

[0030] Examples of typical dimensions for an oven for domestic use according to Figs 1 and 2 are B1 - about 333 mm, B2 - about 325 mm; cavity height (over the bottom plate) - about 185 mm; and cavity depth - about 370 mm.

[0031] Fig. 3 shows a schematic vertical cross-section of the same kind as in Fig. 2, which illustrates another embodiment of an oven according to the invention. The latter differs from the oven according to Figs 1 and 2 with respect to the design of the sloping side wall and the microwave feeding.

[0032] In this example, the sloping side wall 8' in Fig. 2 has a lower part 21, which is vertical, and an upper inward-sloping part 22. The inward slope begins about halfway up the side wall and amounts to about 6°. The horizontal cross-section decrease adjacent to the cavity ceiling is here somewhat larger than in the oven according to Figs 1 and 2, typically about 10 mm.

[0033] In Fig. 3 the microwave feeding is done through

a rectangular ceiling slot 10', which is centrally located in the cavity ceiling 5 and whose long side is parallel to the cavity side walls 7 and 8' and which is fed by the intermediary of a waveguide device 14' arranged on the cavity ceiling.

[0034] As the skilled person will appreciate, the invention is not limited to the examples shown, and modifications are possible within the scope of the appended claims. For example, it is possible to divide up the side wall slope between the two opposing side walls.

Claims

1. A microwave oven comprising a rectangularly parallelepipedal cavity and a microwave source for feeding microwaves into the cavity (2) connected thereto, **characterised in that** the cavity has, in relation to its bottom cross-section, an upwardly decreasing horizontal cross-section, the cavity being rectangularly parallelepipedal except for the inward slope of a cavity side wall (8, 8') adjacent a front vertical wall on the inside of a front door (3), the inward slope beginning halfway up the side wall (8, 8').
2. A microwave oven according to claim 1, **characterised in that** cavity side wall (7), which opposes said sloping side wall (8, 8') is provided with at least one slot opening (10) for the feeding of microwaves located at the top.
3. A microwave oven according to claim 1 or 2, **characterised in that** it is provided with a slot opening (10') in the cavity ceiling (5) for the feeding of microwaves, the slot opening extending transversely of a vertical plane, in which the horizontal cavity width decreases upwards.
4. A microwave oven according to any one of claims 1-3, **characterised in that** the horizontal cross-section of the cavity has a depth which is from about 85% to about 120% of the width.
5. A microwave oven according to any one of claims 1-4, **characterised in that** cross-section width at the top of the cavity (2) is in the interval from about 315 mm to about 335 mm, and that the cross-section width is from about 8 to about 15 mm larger at the bottom.
6. A microwave oven according to any one of claims 1-5, **characterised in that** the cross-section width at the top of the cavity (2) is in the interval from about 385 mm to about 410 mm, and that the cross-section width is from about 8 to about 15 mm larger at the bottom.
7. A microwave oven according to claim 5 or 6, **char-**

acterised in that the cavity (2) has a height of from about 150 mm to about 220 mm.

8. A method for microwave feeding of a rectangularly parallelepipedal microwave oven cavity, **characterised in that** in and for equalisation of the effect of the microwaves in the cavity, the mode balance of the microwave field is affected by the cavity being given, in relation to the horizontal cavity bottom cross-section, an upwardly decreasing horizontal cross-section at least in the upper part of the cavity is present, the decreasing horizontal cross-section being achieved by at least half way up of a cavity side wall (8,8') being sloped inwards, such cavity side wall being adjacent a front vertical wall on the inside of a front door.
9. A method according to claim 8, **characterised in that** microwaves are fed into the cavity through at least one opening (10) located at the top in a cavity side wall (7) opposing the inward sloping side wall (8,8').
10. A method according to claim 8 or 9, **characterised in that** microwaves are fed into the cavity through an opening (10') in the cavity ceiling (5).

Patentansprüche

1. Mikrowellenofen, umfassend einen rechteckigen, parallelepipeden Hohlraum sowie eine Mikrowellenquelle zum Zuführen von Mikrowellen in den Hohlraum (2), die damit verbunden ist, **dadurch gekennzeichnet, dass** der Hohlraum in Bezug auf seinen Bodenquerschnitt einen nach oben hin kleiner werdenden horizontalen Querschnitt aufweist und der Hohlraum außer in Bezug auf die Innenneigung einer Hohlraum-Seitenwand nahe einer vorderen vertikalen Wand an der Innenseite einer Vordertür (3) ein rechteckiges Parallelepiped ist, wobei die Innenneigung auf halber Höhe der Seitenwände (8, 8') beginnt.
2. Mikrowellenofen gemäß Anspruch 1, **dadurch gekennzeichnet, dass** eine Hohlraum-Seitenwand (7), die der geneigten Seitenwand (8, 8') gegenübersteht, mit zumindest einer an der Oberseite platzierten Schlitzöffnung (10) für die Zufuhr von Mikrowellen versehen ist.
3. Mikrowellenofen gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** er mit einer Schlitzöffnung (10') in der Hohlraumdecke (5) zur Zufuhr von Mikrowellen versehen ist, wobei sich die Schlitzöffnung transversal zu einer vertikalen Ebene, in der die horizontale Breite des Hohlraums nach oben hin abnimmt, erstreckt.

4. Mikrowellenofen gemäß einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der horizontale Querschnitt des Hohlraums eine Tiefe aufweist, die von etwa 85% bis zu etwa 120% der Breite entspricht.
5. Mikrowellenofen gemäß einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Querschnittsbreite oben im Hohlraum (2) im Intervall von etwa 315 mm bis zu etwa 335 mm liegt und dass die Querschnittsbreite von etwa 8 bis etwa 15 mm größer als der Boden ist.
6. Mikrowellenofen gemäß einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Querschnittsbreite oben im Hohlraum (2) im Intervall von etwa 385 mm bis etwa 410 mm liegt und dass die Querschnittsbreite von etwa 8 bis etwa 15 mm größer als der Boden ist.
7. Mikrowellenofen gemäß Anspruch 5 oder 6, **dadurch gekennzeichnet, dass** der Hohlraum (2) eine Höhe von etwa 150 mm bis etwa 220 mm aufweist.
8. Verfahren zur Zufuhr von Mikrowellen in einen rechteckigen, parallelepipeden Mikrowellenofen-Hohlraum, **dadurch gekennzeichnet, dass** in und zum Ausgleich des Effekts der Mikrowellen im Hohlraum das Modus-Gleichgewicht des Mikrowellenfelds durch den vorgegebenen Hohlraum in Bezug auf den horizontalen Querschnitt des Hohlraumbodens und eines nach oben hin abnehmenden horizontalen Querschnitt zumindest im oberen Teil des Hohlraums beeinflusst wird, wobei der abnehmende horizontale Querschnitt durch eine Innenneigung der Hohlraum-Seitenwand (8, 8') zumindest ab der halben Höhe erreicht wird, wobei diese Hohlraum-Seitenwand zu einer vorderen vertikalen Wand an der Innenseite einer Vordertür benachbart ist.
9. Verfahren gemäß Anspruch 8, **dadurch gekennzeichnet, dass** die Mikrowellen durch zumindest eine Öffnung (10) in den Hohlraum zugeführt werden, die oben in einer Hohlraum-Seitenwand (7) platziert ist, die der nach innen geneigten Seitenwand (8, 8') gegenübersteht.
10. Verfahren gemäß Anspruch 8 oder 9, **dadurch gekennzeichnet, dass** die Mikrowellen durch eine Öffnung (10') in der Hohlraumdecke (5) in den Hohlraum befördert werden.

Revendications

1. Four à micro-ondes comprenant une cavité parallélépipède rectangulaire et une source de micro-ondes

permettant d'introduire des micro-ondes dans la cavité (2) connectée à celle-ci,

caractérisé en ce que la cavité a, par rapport à sa section en coupe de fond, une section en coupe horizontale rétrécissant vers le haut, la cavité étant parallélipède rectangulaire à l'exception de l'inclinaison vers l'intérieur d'une paroi latérale de la cavité (8, 8'), adjacente à une paroi verticale frontale à l'intérieur d'une porte frontale (3), l'inclinaison vers l'intérieur ne commençant pas plus qu'à mi-hauteur de la paroi latérale (8, 8').

2. Four à micro-ondes selon la revendication 1, **caractérisé en ce que** la paroi latérale de la cavité (7), qui fait face à ladite paroi latérale inclinée (8, 8'), est munie d'au moins une ouverture en fente (10) permettant d'introduire les micro-ondes, située au sommet. 15
3. Four à micro-ondes selon la revendication 1 ou 2, **caractérisé en ce qu'il** comporte une ouverture en fente (10') dans le plafond de la cavité (5) pour l'introduction des micro-ondes, l'ouverture en fente s'étendant de manière transversale par rapport à un plan vertical, dans lequel la largeur de la cavité horizontale rétrécit vers le haut. 20 25
4. Four à micro-ondes selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** la section en coupe horizontale de la cavité a une profondeur allant d'environ 85 % à environ 120 % de la largeur. 30
5. Four à micro-ondes selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** la largeur de la section au sommet de la cavité (2) est dans l'intervalle allant d'environ 315 mm à environ 335 mm et **en ce que** la largeur de la section en coupe est d'environ 8 à environ 15 mm plus large que le fond. 35 40
6. Four à micro-ondes selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** la largeur en section en coupe au sommet de la cavité (2) est dans l'intervalle allant d'environ 385 mm à environ 410 mm et **en ce que** la largeur en section en coupe est d'environ 8 à environ 15 mm plus large au niveau du fond. 45
7. Four à micro-ondes selon la revendication 5 ou 6, **caractérisé en ce que** la cavité (2) a une hauteur allant d'environ 150 mm à environ 220 mm. 50
8. Procédé permettant d'alimenter en micro-ondes une cavité de four à micro-ondes parallélipède rectangulaire, **caractérisé en ce que** dans et pour l'égalisation de l'effet des micro-ondes dans la cavité, l'équilibre des modes du champ de micro-ondes est affecté par le fait qu'on donne à la cavité, par rapport 55

à la section en coupe du fond de la cavité horizontale, une section en coupe horizontale rétrécissant vers le haut au moins dans la partie supérieure de la cavité, la section en coupe horizontale décroissante étant obtenue en inclinant vers l'intérieur une paroi latérale de la cavité (8, 8') au moins à mi-hauteur, ladite paroi latérale de cavité étant adjacente à une paroi verticale frontale à l'intérieur d'une porte frontale.

9. Procédé selon la revendication 8, **caractérisé en ce que** les micro-ondes sont introduites dans la cavité par au moins une ouverture (10) située au sommet dans une paroi latérale de cavité (7) située en face de la paroi latérale inclinée vers l'intérieur (8, 8').
10. Procédé selon la revendication 8 ou 9, **caractérisé en ce que** les micro-ondes sont introduites dans la cavité par une ouverture (10') dans le plafond de la cavité (5).



