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(54) **MICROWAVE DEVICE**

MIKROWELLENVORRICHTUNG

DISPOSITIF A MICRO-ONDES

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(56) References cited:
**US-A- 5 424 518**

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## Description

**[0001]** Microwave devices are used, inter alia, for converting electrical energy to heat. The use is limited to substances with dielectric molecules. Most common among such substances is water. The conversion to heat occurs within the material. Thus, one is spared diffusion processes, which may be very slow in materials with isolating properties. One example of small scale use of microwave technique is microwave ovens for domestic use. Similar units, with one open side, have been used for some time for drying, sanifying or other similar treatments of building details with very satisfying results. See for instance PCT/SE95/00219, WO95/23945.

**[0002]** US 5 424 518 A discloses a method and an apparatus according to the preambles of claim 1 and 3, respectively, and relates to an arrangement for simultaneous treatment of objects with heated air and microwave energy. The only more important difference in relation to conventional microwave units is that the blowing fan, proposed to be common for several microwave units, may be over-dimensioned to carry away water vapour, which is produced at the use of the units. No arrangement is proposed for making the cooling of the microwave generators more efficient. Instead the equipment design according to the drawings is such so that the cooling air passes the cooling flanges of the magnetrons at right angles. As shown below, this gives low cooling effect due to stagnant air cushions between the flanges.

**[0003]** Beside a magnetron microwave unit usually comprises a power package consisting of a transformer and a resonance circuit coupled to the transformer. Other electronic details for the control of the unit may occur too. The magnetron and other electronic equipment are usually placed together in an upper part of the unit. Usually this upper part is divided from the lower part by a perforated plate or a grille, which allows air passage, but prevents passage of microwaves. The magnetron is mounted on the perforated plate so that the microwave radiation occurs below the plate. Thus, the upper chamber is kept essentially free from microwaves.

**[0004]** In the upper chamber the temperature must not rise to more than 80°C at most. The magnetron and transformer and other electronic equipment generate heat and must be cooled not to be destroyed by the generated heat. For large magnetrons water cooling is often used. For smaller and cheaper magnetrons, used for domestic ovens etc., air cooling is used. A standard design for such magnetrons is a parallellepipedic box with a solid upper side, a solid underside with a projecting transmitting antenna, which radiates microwaves, two opposite, solid sides and two opposite, open sides to allow entrance of cooling air. Usually one is satisfied by blowing in cooling air in the chamber where the electronic equipment is situated and let convection control the cooling air distribution. No special measures for controlling air flow are common. The air passes the perforated plate and is let out through the gap between the lower border of the plate box and the upper surface of the treated object. In this way the .cooling air fulfils a double function, i.e. it serves both to dispose of heat excess from the electronic equipment and to dispose of the water vapour released from the object at microwave treatment.

**[0005]** From practical reasons, when microwave units of mentioned air cooled type are used in small scale equipment for drying or similar, placing the intake for cooling air at the upper side is usually appropriate. At drying and similar operations it is desirable that the magnetron can sustain lengthy loading at maximal power. This puts special emphasis on efficient cooling. In a domestic oven the conversion efficiency, which is often low for this type of devices, does not mean very much from the economical point of view. In contrast hereto, for mentioned use for drying and similar the conversion efficiency is essential not just directly economically, but also because available power is usually limited. Therefore, a low conversion efficiency means that the time for achieving. a desired treatment result has to be increased.

**[0006]** According to the present invention the cooling efficiency is substantially increased by active control of the flow pattern of the cooling air as defined in the characterizing features of claim 1 and claim 3. This arrangement makes it possible to increase the output of microwave power without increasing the input of electric power. Means of assistance at this increase of the output power may be an ameliorated power package and a control system for the magnetron.

**[0007]** In the figures 1 and 2 a preferred embodiment of the invention is shown. In the figures all details have been deleted that do not directly influence the cooling.

Fig. 1 shows a side view with removed front of a unit according to an especially preferred embodiment of the invention.

Fig. 2 shows a horizontal cross section through the line A - A in fig. 1.

**[0008]** In the figures 1 stands for the downwards open apparatus case, 2 for a filter provided air intake, 3 for a primary blower for blowing in cooling air in the electronic department, 4 for a magnetron box with open sides 4a and solid sides 4b, 5 stands for a secondary blower for the control of the air flow through the magnetron box, 6 is an airlock with solid sides except downwards, 7 stands for a perforated plate, which allows air passage but prevents leakage of microwaves, 8 stands for an ameliorated power package, 9 stands for arrows showing the flow direction of the cooling air. A unit according to common technique may have the same design with the exception that the power package 8, the blower 5 and the airlock 6 are missing.

**[0009]** At addition of cooling air from above it is at conventional design of the microwave unit large risk for get-

ting a stagnant air zone in whole or parts of the magnetron box. This refers especially to the space between the cooling flanges. Air is a very good insulator and therefor, heat transport must happen mainly by convection, which is hindered in the narrow spaces. The stagnant air impairs the cooling and limits the power that can be taken out continuously from the unit. As electrical installations, fuses etc. must be adjusted to the maximum power the limitation means that available power cannot be used in an optimal way.

**[0010]** According to the invention the effect of the mentioned limitation is reduced substantially by that the air cooling is improved by means of a cross flow through the magnetron box 4. In this way one gets a directional air flow even in the narrow clefts between the flanges. In contrast to conventional designs inclusive the one of mentioned US 5 424 518 A, where one can use just the outer parts of the flanges for cooling, this new design achieves that the main part of the surface of the flanges assumes an active role in the cooling.

**[0011]** Cross flow is achieved by means of a side mounted secondary blower 5, which aspires or blows air through the box 4. Flow technology calculations and practical tests show that the placement of the blower 5 and the flow direction 9, which is shown in the figures, i.e. to let the blower aspire air through the box gives best results. A movement of the blower 5 to the other side of the magnetron 4 with the same flow direction 9, i.e. that the blower blows air through the magnetron box gives almost as good effect. The worst result is obtained with the same blower placement and reversed flow direction, but even this unfavourable result shows better cooling than the usual, passive cooling.

**[0012]** The method for ameliorated cooling has been described above with a start from the use of a secondary blower 5, which treats a partial flow of the cooling air that the primary blower 3 blows in. It should be observed that the increased air velocity that a secondary blower may give is very advantageous with respect to the cooling.

**[0013]** To use of the advantages of the new method of cooling better, the magnetron should be equipped with a more advanced control device than the conventional one. Therefore, in an especially preferred embodiment the filament current is controlled with respect to the emission state of the cathode instead of with respect to the power level of the magnetron. The latter are the conventional method. The emission state may be detected by, for instance, detecting of dynamic impedance or random noise, a light sensor, measuring the temperature of the magnetron or measuring the anode current. Examples of different methods are given in SE9603291-7, JP 5-67492, EP 449275 and DE 4238199.

**[0014]** Magnetrons for technical purposes are usually fed by a ferroresonant power package. Such a package includes a transformer with a comparatively large distributed inductance. With one or two capacitors the distributed inductance creates a series resonant circuit, which is tuned to the net frequency, 50 or 60 Hz. Unloaded the circuit has a high Q-value and gives after rectification a voltage to the magnetron, which during a large part of the period is the same level as its working voltage. The current fed to the magnetron will, dependant on the design of the power package, pulsate with 50 or 100 respectively with 60 or 120 Hz. Therefore, during a substantial time the current will be almost zero. The high frequency power from the magnetron will be modulated in the same way. The oscillation of the magnetron will be restarted for each pulse and one gets strong side bands to the work frequency.

**[0015]** This invention refers to units of a type that must often work under very difficult loading conditions. The conventional method for power feeding gives under these conditions instability with respect to the high frequency power. It is important that the power feeding remains stabile under all conditions and that the mentioned instability is eliminated. It is also important that the units do not disturb other electric equipment through feedback coupling to the electric system more than absolutely unavoidably. Therefor, in an especially preferred embodiment of the invention a new power package is used where the conversion from common alternating voltage to high voltage unidirectional current is done in several steps. Such a power package is the object of Swedish patent application No 9603292-5 and PCT/SE97/01520.

**[0016]** A preferred method of the mentioned invention comprises the stages a) conversion of alternating current to unidirectional current; b) conversion of the unidirectional current to high frequency alternating current; c) transforming of the high frequency alternating current to a high voltage alternating current with high frequency; and d) rectification of the high voltage alternating current to high voltage unidirectional current for feeding the magnetron. Power regulation is done in the stage a) with respect to the power fed in stage b). A power package designed according to the mentioned invention gives an almost constant unidirectional current.

## Claims

1. Method for cooling of a magnetron (4) with flowing air in a microwave unit, which magnetron produces microwaves and uses input power within the range of 1 to 4 kW and is intended for drying or other similar treatment of objects not enclosed in a microwave oven, said unit further comprising a primary blower (3) and equipment for governing part of the air flow from the primary blower (3) to obtain a forced air stream over the cooling surfaces of the magnetron (4), **characterized in that** part of the air flow from the primary blower is governed by a secondary blower as said equipment so that a forced flow over the cooling surfaces of the magnetron (4)

is obtained and stagnant air cushions between the cooling flanges are eliminated.

2. The method of claim 1, **characterized in that** the cooling air of the magnetron (4) is governed downwards by means of an airlock (6) through a perforated floor (7).

3. A microwave unit with input power in the range of 1 to 4 kW, intended for drying or other similar treatment of objects that cannot be enclosed inside a microwave oven, comprising an air cooled magnetron (4), required electronic equipment for controlling the unit, and a primary blower (3), said unit being provided with equipment for governing part of the air flow from the primary blower (3) to obtain a forced air stream over the cooling surfaces of the magnetron (4), **characterized in that** said equipment is a secondary blower (5) using part of the air flow from said primary blower (3) in order to provide a forced air flow over the cooling surfaces of the magnetron (4) such that stagnant air cushions between the flanges of the magnetron are avoided.

4. The microwave unit of claim 3, **characterized in that** it is provided with a power package (8), the working principle of which comprises the stages a) conversion of alternating current to unidirectional current; b) conversion of the unidirectional current to high frequency alternating current; c) transforming of the high frequency alternating current to a high voltage alternating current with high frequency; and d) rectifying of the high voltage alternating current to high voltage unidirectional current for feeding the magnetron, at which power regulation is done in the stage a) with regard to the power fed in stage b).

**Patentansprüche**

1. Verfahren zum Kühlen eines Magnetrons (4) mit strömender Luft in einer Mikrowelleneinheit, wobei das Magnetron Mikrowellen erzeugt und eine Eingangsleistung im Bereich von 1 bis 4 kW verwendet und zum Trocknen oder einer anderweitigen ähnlichen Behandlung von Objekten dienen soll, die nicht in einem Mikrowellenofen eingeschlossen sind, wobei die Einheit weiter ein primäres Gebläse (3) und Einrichtungen zum Leiten eines Teils des Luftflusses von dem primären Gebläse (3), um einen erzwungenen Luftsstrom über die Kühloberflächen des Magnetrons (4) zu erhalten, aufweist, **dadurch gekennzeichnet, dass** der Teil des Luftflusses von dem primären Gebläse durch ein zweites Gebläse als die Einrichtung geleitet wird, so dass ein erzwungener Fluss über die Kühlflächen des Magnetrons (4) erhalten wird und stehende Luftpolster zwischen den Kühlflanschen eliminiert werden.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kühlluft des Magnetrons (4) mit einer Luftschleuse (6) durch einen gelochten Boden (7) nach unten gelenkt wird.

3. Mikrowelleneinheit mit einer Eingangsleistung im Bereich von 1 bis 4 kW, die zum Trocknen oder einer anderen ähnlichen Behandlung von Objekten dienen soll, die nicht innerhalb eines Mikrowellenofens eingeschlossen werden können, mit einem luftgekühlten Magnetron (4), mit der benötigten elektronischen Ausrüstung zum Steuern der Einheit und mit einem primären Gebläse (3), wobei die Einheit mit einer Einrichtung zum Leiten eines Teils des Luftflusses von dem primären Gebläse (3) zum Erhalten eines erzwungenen Luftstroms über die Kühloberflächen des Magnetrons (4) versehen ist, **dadurch gekennzeichnet, dass** die Einrichtung ein zweites Gebläse (5) ist, das einen Teil des Luftflusses von dem primären Gebläse (3) verwendet, um einen erzwungenen Luftfluss über die Kühloberflächen des Magnetrons (4) zu liefern, so dass stehende Luftpolster zwischen den Flanschen des Magnetrons vermieden werden.

4. Mikrowelleneinheit nach Anspruch 3, **dadurch gekennzeichnet, dass** sie mit einer Leistungsversorgungseinheit (8) ausgestattet ist, deren Arbeitsprinzip folgende Stufen umfasst:

   a) Umwandeln von Wechselstrom in einsinnigen Strom

   b) Umwandeln des einsinnigen Stroms in einen hochfrequenten Wechselstrom,

   c) Transformieren des hochfrequenten Wechselstroms auf einen Hochspannungswechselstrom mit hoher Frequenz, und

   d) Gleichrichten des Hochspannungswechselstroms auf einen einsinnigen Strom hoher Spannung zum Einspeisen in das Magnetron, wobei die Leistungsregelung in Stufe a) in Bezug auf die Stufe b) eingespeiste Leistung erfolgt.

**Revendications**

1. Procédé de refroidissement d'un magnétron (4) par un écoulement d'air dans une unité à micro-ondes, lequel magnétron produit des micro-ondes et utilise une puissance d'entrée comprise dans la plage de 1 à 4 kW et est prévu pour le séchage ou tout autre traitement similaire d'objets non contenus dans un

four à micro-ondes, ladite unité comprenant, en outre, un ventilateur principal (3) et un équipement pour orienter la partie de l'écoulement d'air provenant du ventilateur principal (3) pour obtenir un flux d'air forcé sur les surfaces de refroidissement du magnétron (4), **caractérisé en ce qu'**une partie de l'écoulement d'air provenant du ventilateur principal est orientée par un ventilateur secondaire, en tant qu'équipement susdit, de telle sorte qu'un écoulement forcé sur les surfaces de refroidissement du magnétron (4) est obtenu et que les coussins d'air stagnant entre les ailettes de refroidissement sont éliminés.

**2.** Procédé selon la revendication 1, **caractérisé en ce que** l'air de refroidissement du magnétron (4) est dirigé vers le bas, au moyen d'un sas (6) prévu à travers un plancher perforé (7).

**3.** Unité à micro-ondes ayant une puissance d'entrée comprise dans la plage de 1 à 4 kW, destinée au séchage ou à tout autre traitement d'objets qui ne peuvent pas être enfermés dans un four à micro-ondes, comprenant un magnétron refroidi à l'air (4), un équipement électronique requis pour commander l'unité, et un ventilateur principal (3), ladite unité étant munie d'un équipement pour orienter une partie de l'écoulement d'air provenant du ventilateur principal (3), afin d'obtenir un flux d'air forcé sur les surfaces de refroidissement du magnétron (4), **caractérisé en ce que** ledit équipement est un ventilateur secondaire (5), utilisant une partie de l'écoulement d'air provenant dudit ventilateur primaire (3) pour fournir un écoulement d'air forcé sur les surfaces de refroidissement du magnétron (4), de telle sorte que les coussins d'air stagnant entre les ailettes de refroidissement sont évités.

**4.** Unité à micro-ondes selon la revendication 3, **caractérisé en ce qu'**il est muni d'un bloc d'alimentation (8), dont le principe de fonctionnement comprend les étapes de a) conversion du courant alternatif en un courant unidirectionnel ; b) conversion du courant unidirectionnel en un courant alternatif à haute fréquence ; c) transformation du courant alternatif à haute fréquence en un courant alternatif à haute tension, avec la haute fréquence ; et d) redressement du courant alternatif à haute tension en un courant unidirectionnel à haute tension destiné à alimenter le magnétron, dans lequel une régulation de puissance est effectuée au cours de l'étape a) par rapport à la puissance fournie au cours de l'étape b).

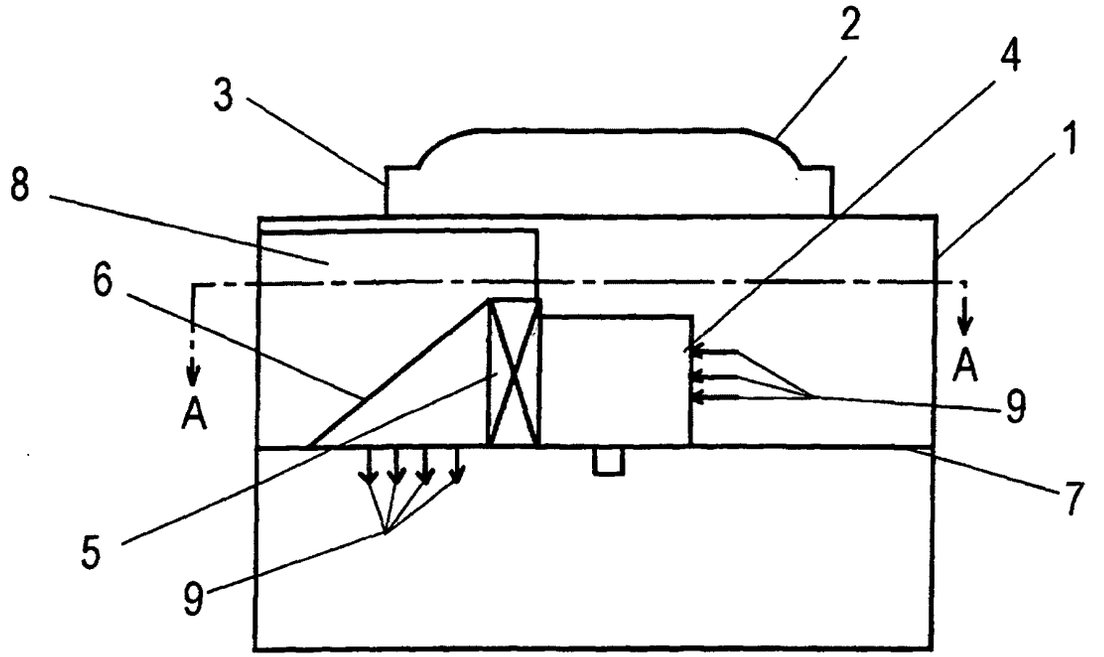



Fig. 1

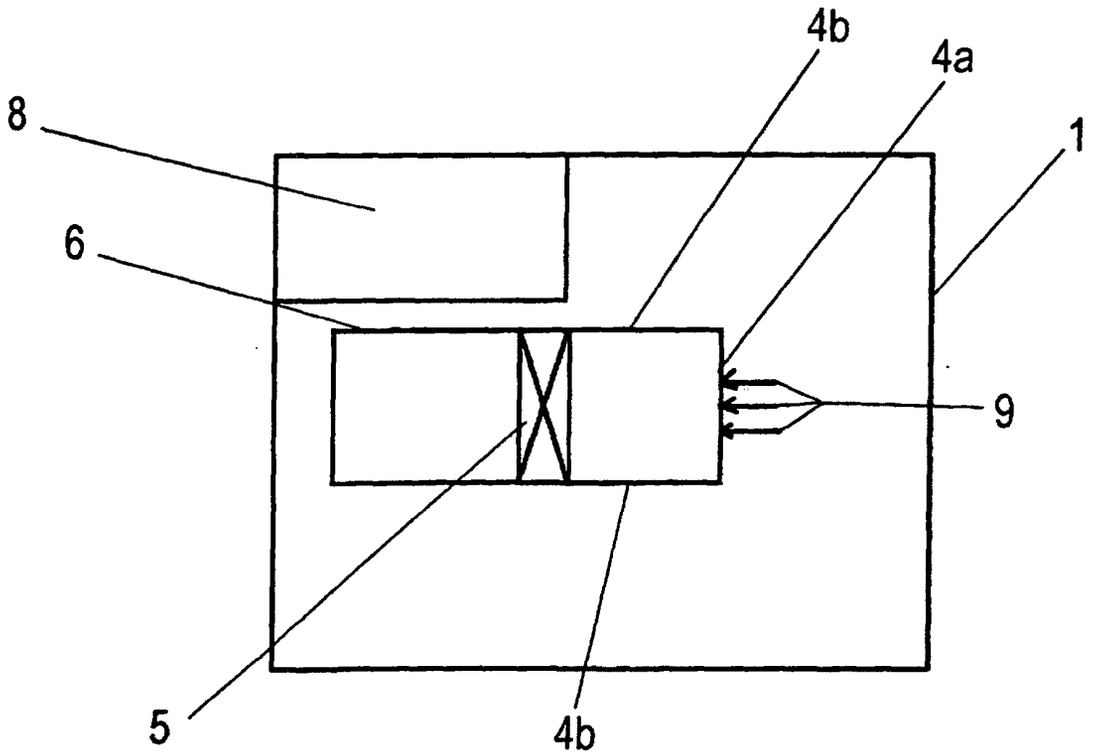



Fig. 2