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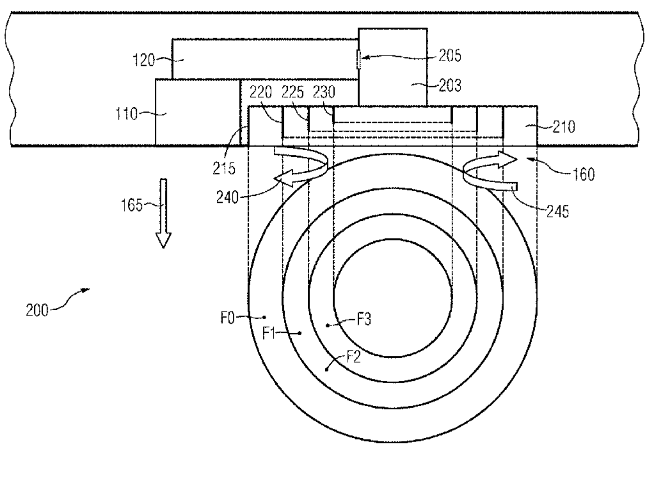
(54) Title: MICROWAVE-ENERGY FEEDING ARRANGEMENT, MICROWAVE HEATING ARRANGEMENT, MICROWAVE OVEN, METHOD FOR MANUFACTURING A MICROWAVE OVEN AND METHOD FOR HEATING FOOD

FIG 2



(57) Abstract: Microwave energy feeding arrangement (120, 203, 210), at least comprising: - a waveguide (120); and - a cylindrical-shaped corrugated horn antenna (203).

WO 2015/118101 A1

Description

MICROWAVE-ENERGY FEEDING ARRANGEMENT, MICROWAVE HEATING ARRANGEMENT, MICROWAVE OVEN, METHOD FOR MANUFACTURING A MICROWAVE OVEN AND METHOD FOR HEATING FOOD

Microwave applications are ubiquitous in the technical field. They are used for communication purposes, e.g. satellite communication or long-range communication lines and in household appliances respectively kitchen environments to heat food.

In particular in modern food preparation methods, microwave ovens are used to bring precooked food to a consumable temperature. This helps saving time and energy, as only the food to be heated is exposed to the microwaves, and thus energy used for food preparation is used very efficiently. Microwave-feeding arrangements are generally known from the communication technology and are often used to feed microwave radiation to a parabolic antenna which then reflects it.

U.S. patent document 5,486,839 discloses a conical corrugated microwave feed horn. It particularly relates to a low-cost conical corrugated feed horn for use in an offset parabolic microwave antenna. A feed horn illustrated in Fig. 1 has a cylindrical portion and a conical flat section which has a plurality of slots in a corrugated region.

Satellite communication applications usually do not require high amounts of energy, and on the other hand necessitate high precision in control of the microwave signal that is transmitted in order to be suitable for communication applications to reliably transmit communication signals over long distances. In a kitchen environment conversely, the transmission of high energy is required, which basically needs to be confined thoroughly into a microwave oven and has to be guided in a proper manner to be fully exposed to food or other substances to be heated.

In household appliances or kitchen environments, energy efficiency of the used appliances is subject of more and more concern. The general public opinion more and more focuses on low energy consumption and avoiding the related atmospheric pollution. Waste of energy is believed to cause the greenhouse effect. This motivates consumers to buy appliances that use less energy in comparison to older designs and thus also save money in view of related energy costs.

The invention is based on the problem to improve the energy efficiency of a microwave energy feeding arrangement.

This problem is solved by a microwave feeding arrangement according to claim 1, a microwave heating arrangement according to claim 11, a microwave oven according to claim 14, a method for manufacturing a microwave oven according to claim 17 and a method for heating food according to claim 19.

According to claim 1, the microwave energy feeding arrangement comprises a waveguide and a cylindrical-shaped corrugated horn antenna.

In an embodiment, the waveguide is intended to guide microwaves along a propagation direction, especially a main propagation direction.

Preferably, the waveguide is rectangular or at least substantially rectangular. More preferably, the waveguide is rectangular or at least substantially rectangular in its cross section perpendicular to the propagation direction, especially the main propagation direction of the microwaves.

The rectangular or at least substantially rectangular waveguide is, in a preferred embodiment, delimited by four side surfaces, which are preferably extending along the propagation direction, especially along the main propagation direction of the microwaves.

Each side surface can have a flat or at least slightly concave or convex shape.

Preferably, three of the four side surfaces are formed by one single metal part, especially one single deep drawn metal part, wherein the three side surfaces adjoin each other on edge areas. The three side surfaces can have a flat or at least substantially flat shape.

In a preferred embodiment, the edge areas are rounded, more preferably with a radius of at least 1mm or of at least 2mm.

The cylindrical corrugated horn antenna can comprise a cylindrical waveguide and the rectangular or at least substantially rectangular waveguide can be adapted to excite the cylindrical waveguide.

Advantageously, a microwave energy feeding arrangement according to an embodiment of the present invention combines a waveguide with a cylindrical corrugated horn antenna, thereby providing a minimum configuration to reliably transmit high amounts of microwave energy in a confined environment over short distances with minimum energy losses.

Beneficially, according to a further development of an embodiment of the microwave energy feeding arrangement according to the present invention, the waveguide is rectangular and excites a cylindrical waveguide inside of the cylindrical corrugated horn antenna, thus using a waveguide that is widely used in microwave applications and combining it with a horn antenna by achieving generation of microwave radiation in a transverse electromagnetic mode, which is highly suitable to heat food substances due to its homogenous energy distribution Further beneficially by avoiding the use of so-called “mode stirrers” to distribute microwaves inside the oven according to the presented solution moveable parts inside the oven and a motor to move them can be avoided. This advantageously simplifies the manufacturing process, enhances the reliability and saves parts.

Advantageously, a further development of an embodiment of the microwave energy feeding arrangement according to the present invention comprises a coupling iris between the waveguide and the cylindrical part of the corrugated horn antenna, thus allowing for an energy-efficient coupling between the two different waveguides and optimum transmission conditions.

Favorably, a further development of an embodiment of the microwave energy feeding arrangement according to the present invention has a corrugated antenna part with protrusions that allow the corrugated horn antenna to emanate microwave energy at different frequencies and thus enabling e.g. food to be heated and penetrated at different depths.

Further advantageously, according to a further development of an embodiment of the microwave energy feeding arrangement of the present invention, the different protrusions have a different length to be optimally adapted to the microwave energy and the respective frequency of transmission in order to further optimize energy efficiency in transmission of the microwave energy.

Beneficially, according to a further development of an embodiment of the microwave energy feeding arrangement according to the present invention, the corrugated horn antenna is covered by a dielectric separating plate in order to further improve the energy efficiency and transmission characteristics of the microwave energy feeding arrangement. Beneficially such a dielectric plate has also the function to protect the antenna against dust and vapor, which can badly impact on the performance. Thus the reliability is increased and the efficiency is improved.

Favorably, according to a further development of an embodiment of the microwave energy feeding arrangement according to the present invention, the waveguide excites circular polarized multi-frequency electromagnetic waves of different frequencies, which allows the corrugated horn antenna to emanate microwaves in different frequencies and thus expose substances to be heated with microwaves that have different penetration depths and thus provides for a thorough and energy-efficient heating.

Advantageously, a microwave heating arrangement according to the present invention comprises a microwave energy feeding arrangement in combination with a microwave energy source such as a magnetron. In this manner, a microwave heating arrangement is provided that uses reliable components the manufacturing technologies of which are well established and thus are suitable also for products to be used in the consumer market, such as kitchen appliances and microwave ovens.

Favorably, according to a further development of an embodiment of the microwave heating arrangement according to the present invention, this is adapted to simultaneously emanate microwaves of four different frequencies, which allows an optimum heating of substances respectively food to be heated due to the different energy and penetration characteristics of microwaves with different frequencies. At the same time, corrugated horn antennas suitable to emanate four different frequencies are compact enough to be fitted into a microwave oven.

Advantageously, according to a further development of the microwave heating arrangement according to the present invention, the rectangular waveguide is coupled to the cylindrical waveguide, because this combination provides smooth coupling for high-energy microwaves, while at the same time minimizing the losses.

Advantageously, a microwave oven according to the present invention comprises the microwave heating arrangement according to the present invention, because such an arrangement is optimally suited to be used in home appliances such as microwave ovens and improves the energy efficiency of a microwave oven.

In an embodiment, the microwave oven comprises a cooking cavity for the items to be applied by the microwaves, wherein the cooking cavity is limited at its upper side by a ceiling.

Preferably, at least one of the side surfaces of the rectangular or of the at least substantially rectangular waveguide is formed by the ceiling, which reduces the amount of material which is needed.

The ceiling of the cooking cavity can be of at least slightly concave or convex shape, so that preferably also the at least one of the side surfaces of the waveguide has an at least slightly concave or convex shape, which improves the stability of the arrangement.

Advantageously, according to a further development of a microwave oven according to an embodiment of the present invention, the cylindrical corrugated horn antenna is mounted next to a ceiling of the microwave oven, thus allowing to expose the cooking cavity with a homogeneously distributed microwave pattern.

Advantageously, a method to manufacture a microwave oven according to the present invention provides for the assembly of a new and energy-efficient microwave oven with reliable technical components that are well-established in technology and thus can rely on known manufacturing technologies, which is suitable for household and kitchen appliances.

Beneficially, a further development of a microwave oven according to an embodiment of the present invention provides a coupling between a rectangular waveguide and a cylindrical waveguide, which guarantees optimum wave coupling and thus optimum energy efficiency.

Beneficially, a method for heating food according to the present invention combines the technical advantages of devices and components that until now have been used in different fields of technology to the surprising effect of an energy-efficient food preparation method.

Subsequently, examples of embodiments of the invention will be further explained on the basis of embodiments shown in drawings, wherein:

Fig. 1 shows a known microwave oven,

Fig. 2 shows a microwave oven using a microwave energy feeding arrangement according to an embodiment of the present invention,

Fig. 3 shows an embodiment of a microwave oven,

Fig. 4 shows a method for manufacturing a microwave oven,

Fig. 5 shows an embodiment of a microwave energy feeding arrangement according to the present invention in a top view and

Fig. 6 shows the embodiment of a microwave energy feeding arrangement from Fig. 5 in a cross-section along line A-A'.

Fig. 1 shows a schematic representation of a microwave heating arrangement used in present microwave ovens. It particularly shows a current microwave system on the market by Electrolux® and can be taken as a generic representation of a common microwave feeding system consisting of magnetron, waveguide, stirrer and cavity.

Reference sign 100 in the upper half of the drawing indicates a side view, whereas a reference sign 105 in the lower half of the drawing indicates a top view of the microwave heating arrangement. The present state of the art uses a magnetron 110 that is coupled to a rectangular waveguide 120. From there, the microwaves are exposed to a $\lambda g/4$ 1-step Chebyshev waveguide transformer 130 and then fed into a stirrer 150 which has a cylindrical back open cavity 155, a dielectric stirrer shaft 145 and stirrer blades 140. The waves are fed into a microwave cavity in a direction 165 through a dielectric separating plate 160.

Fig. 2 shows an example of a microwave heating arrangement according to an embodiment of the present invention, which comprises a microwave feeding arrangement according to an embodiment of the present invention. Here, the microwave feeding is shown in form of a rectangular waveguide that is coupled to a circular horn antenna 203, which terminates in a corrugated part 210. A microwave heating arrangement is completed in this exemplary embodiment by a magnetron 110.

Between the rectangular waveguide 120 and the cylindrical horn of the antenna 203, a coupling iris 205 is provided. Here, the rectangular waveguide acts as a launcher for the microwaves. As can be seen in the drawing, the corrugated part of the cylindrical horn antenna 210 has protrusions 215, 220, 225 and 230 of different lengths. Those correspond to nested concentric circles which emanate different frequencies F0 to F3. On the left side of the drawing, the electrical field 240 has a different direction of rotation than on the right side 245. The corrugated part of the cylindrical horn antenna 210 is covered by a dielectric separating plate 160. Microwaves are emanated in a direction 165 into the microwave oven cavity.

In comparison to the conventional solution, a one-step classical λg/4 Chebyshev waveguide transformer e.g. always imposes a mismatch between the waveguide impedance and the cylindrical cavity impedance. Further, the stirrer of the prior art solution by its rotation and orientation of its blades reflects back some percentage of the microwave energy to the magnetron's antenna, and the VSWR (voltage standing wave ratio) factor is subject to large variations, and the impedance matching will change to a wrong region in the Rieke diagram, and the result is bad microwave power transmission to the cavity with a low efficiency by the prior art solution.

Moreover, the prior art solution has the disadvantage that the stirrer causes a shift in the phase of the electromagnetic waves, which is, however, not enough to improve the microwave distribution, because at the same time there exists a great impedance variation between the magnetron's antenna location point and the whole cavity. As a consequence, the power consumption efficiency of the prior art solution is no more than 50 to 55%, as a great amount of power delivered by the magnetron is lost by reflecting phenomena and heating of the magnetron outside body.

Moreover, the electromagnetic waves have only a linear polarization in form of vertical and horizontal polarization and create a standing wave picture in the microwave cavity with only changing the phase in connection with the stirrer blade position during its rotation, which will not substantially improve the microwave power distribution inside the microwave oven cavity or into the load.

Conversely, the embodiment shown in Fig. 2 provides circular multi-frequency polarized transverse electrical mode, electromagnetic waves in the rectangular microwave oven by a feeding system comprising e.g. a corrugated cylindrical horn antenna excited by a slotted rectangular waveguide, which excites a cylindrical waveguide and the cylindrical waveguide terminates with the cylindrical corrugated horn antenna. Such a configuration as shown in this embodiment will excite circular polarized multi-frequency electromagnetic waves, e.g. to a microwave oven's cavity with F0 = 2,45 GHz, F1 = 5 GHz, F2 = 7,5 GHz and F3 = 10 GHz.

Beneficially, the circular polarized waves will facilitate a very good coupling with any kind of load, and the multi-frequency waves generation will provide a heating effect at various depth penetration coefficients, which will improve the quality of the treated load.

Further advantageously, the power field is more efficiently distributed, and a treatment will take place at various depth levels according to the depth factor for each of the wavelengths excited into the cavity of the microwave oven. Measurements have shown efficiencies over 90% with a constant VSWR regarding the impedance matching with the magnetron's antenna reference point. This leads to an efficiency in terms of main power supply to 75% which is a total 20% difference to the level achieved by the prior art.

Moreover, no moving parts are required. This further facilitates the construction of a microwave oven, as the stirrer and its motor are not required by the solution provided by the present invention.

The inventors have realized that microwave ovens can be improved by changing and improving the microwave feeding arrangement. Fig. 3 shows an example of a microwave oven according to an embodiment of the present invention. The microwave oven 300 has the ceiling 320 and a cooking cavity 310. The heating arrangement inside the microwave oven comprises a e.g. magnetron 110 as energy source, a rectangular waveguide 120 and a cylindrical corrugated horn antenna 203 and 210. For the ease of understanding, components that are generally present at microwave ovens but are not needed for the understanding here have been omitted, such as electronic components to control the activation of the functional parts of the microwave oven as well as operating knobs and displays.

Beneficially, the heating arrangement of the present invention is mounted on the ceiling 320 of the microwave oven 300. The microwave oven according to this embodiment has a less complicated construction as it does not require moving parts like the stirrer in the prior art and thus does not require a motor to drive the stirrer.

Fig. 4 shows an example of a method for manufacturing a micro-wave oven according to the present invention. In the first step, a magnetron is mounted 100, and then a rectangular waveguide is mounted 410. Further, a corrugated horn antenna is mounted 420. Moreover, in a step 430, a cylindrical waveguide is coupled to the rectangular waveguide.

The waveguide 120 is intended to guide micro-waves along a main propagation direction P. The waveguide 120 is rectangular or at least substantially rectangular in its cross section perpendicu-lar to the main propagation direction P of the microwaves, as can be seen from Fig. 5 and Fig. 6.

The rectangular or at least substantially rectangular waveguide 120 is delimited by four side surfaces 121 - 124 which are ex-tending along the main propagation direction P of the micro-waves. Each side surface 121 - 124 has a flat or at least slightly concave or convex shape.

In an embodiment as shown in Fig. 5 as a top view and in Fig. 6 as a cross section along line A - A' of Fig. 5, three side sur-faces 121 - 123 of the four side surfaces 121 - 124 of the wave-guide 120 are formed by one single metal part 125, especially by one single deep drawn metal part 125. The three side surfaces 121 - 123 adjoin each other on edge areas 126, 127.

The three side surfaces 121 - 123 have a flat shape. The edge areas 126 - 127 are rounded, preferably with a radius of at least 1mm or of at least 2mm.

The cylindrical corrugated horn antenna 203 comprises a cylin-drical waveguide 203. The rectangular or at least substantially rectangular waveguide 120 is adapted to excite the cylindrical waveguide 203.

The microwave oven comprises a cooking cavity 310 for the items to be applied by the microwaves. The cooking cavity 310 is limited at its upper side by a ceiling 320, which ceiling 320 is partly shown in Fig. 6.

At least one side surface 124 of the side surfaces 121 - 124 of the rectangular or of the at least substantially rectangular waveguide 120 is formed by the ceiling 320. The ceiling 320 of the cooking cavity 310 is of at least slightly concave or, alternatively, convex shape, so that also the corresponding side surface 124 of the waveguide 120 has an at least slightly concave shape or convex shape when viewed from the inside of the waveguide 120.

List of reference numerals

100	side view of heating arrangement
110	Magnetron
120	Waveguide
121-124	side surfaces
125	single metal part
126-127	edge areas
130	Chebysev waveguide transformer
155	cylindrical back oven cavity with stirrer assembly
150	stirrer
145	dielectric stirrer shaft
160	dielectric separating plate
165	direction towards microwave oven cavity
105	top view
200	heating arrangement
205	coupling iris between waveguide launcher and cylindrical horn antenna
203	cylindrical waveguide
210	corrugated part of the cylindrical horn antenna
215, 220, 225, 230	protrusions of different length
240	electrical field rotation
245	electrical field rotation
F0, ..., F3	different frequencies of microwaves emanated from the corrugated cylindrical horn antenna
300	microwave oven
310	cooking cavity of microwave oven
320	ceiling of microwave oven
400, ..., 430	steps of a method for manufacturing a microwave oven
P	main propagation direction

Claims

1. Microwave energy feeding arrangement (120, 203, 210), at least comprising:
   - a waveguide (120); and
   - a cylindrical-shaped corrugated horn antenna (203).

2. Microwave energy feeding arrangement (120, 203, 210) according to claim 1, wherein
   - the waveguide (120) is rectangular or at least substantially rectangular, wherein
   - preferably the waveguide is intended to guide microwaves along a propagation direction (P), more preferably a main propagation direction (P) and wherein
   - preferably the waveguide (120) is rectangular or at least substantially rectangular in its cross section perpendicular to the propagation direction (P) or to the main propagation direction (P) of the microwaves.

3. Microwave energy feeding arrangement (120, 203, 210) according to claim 2, wherein
   - the rectangular or at least substantially rectangular waveguide (120) is delimited by four side surfaces (121 - 124), which are preferably extending along the propagation direction (P) or along the main propagation direction (P) of the microwaves, wherein
   - especially each side surface (121 - 124) has a flat or at least slightly concave or convex shape.

4. Microwave energy feeding arrangement (120, 203, 210) according to claim 3, wherein
   - three (121 - 123) of the four side surfaces (121 - 124) are formed by one single metal part (125), especially one single deep drawn metal part, wherein
   - the three side surfaces (121 - 123) adjoin each other on edge areas (126 - 127),

- wherein preferably the three side surfaces (121 - 123) have a flat shape and/or
- wherein preferably the edge areas (126 - 127) are rounded, more preferably with a radius of at least 1mm or of at least 2mm.

5. Microwave energy feeding arrangement (120, 203, 210) according to any one of the previous claims, wherein
   - the cylindrical corrugated horn antenna (203) comprises a cylindrical waveguide (203); and
   - the rectangular or at least substantially rectangular waveguide (120) is adapted to excite the cylindrical waveguide (203).

6. Microwave energy feeding arrangement (120, 203, 210) according to any one of the previous claims, comprising a coupling iris (205) between the waveguide (120) and a cylindrical part of the corrugated horn antenna (203).

7. Microwave energy feeding arrangement (120, 203, 210) according to any one of the previous claims, wherein the corrugated horn antenna (203) comprises at least two circular protrusions (215, 220) nested within each other.

8. Microwave energy feeding arrangement (120, 203, 210) according to claim 7, wherein the protrusions (215, 220) have a different length.

9. Microwave energy feeding arrangement (120, 203, 210) according to any one of the previous claims, wherein the corrugated horn antenna (203) is covered by a dielectric separating plate (160).

10. Microwave energy feeding arrangement (120, 203, 210) according to any one of the previous claims adapted to excite circular polarized multi-frequency electromagnetic waves selected from the frequencies 2,45, 5, 7,5 and 10 GHz.

11. Microwave heating arrangement (200) comprising a microwave energy feeding arrangement according to any of the claims 1 to 10 and a magnetron (110) coupled to the waveguide (120).

12. Microwave heating arrangement (200) according to claim 11 adapted to simultaneously emanate microwaves of four different frequencies.

13. Microwave heating arrangement (200) according to any of the claims 11 to 12 in combination with claim 5, wherein the rectangular waveguide (120) is coupled to the cylindrical waveguide (203).

14. Microwave oven (300) at least comprising:
a microwave heating arrangement according to any of the claims 11 to 13.

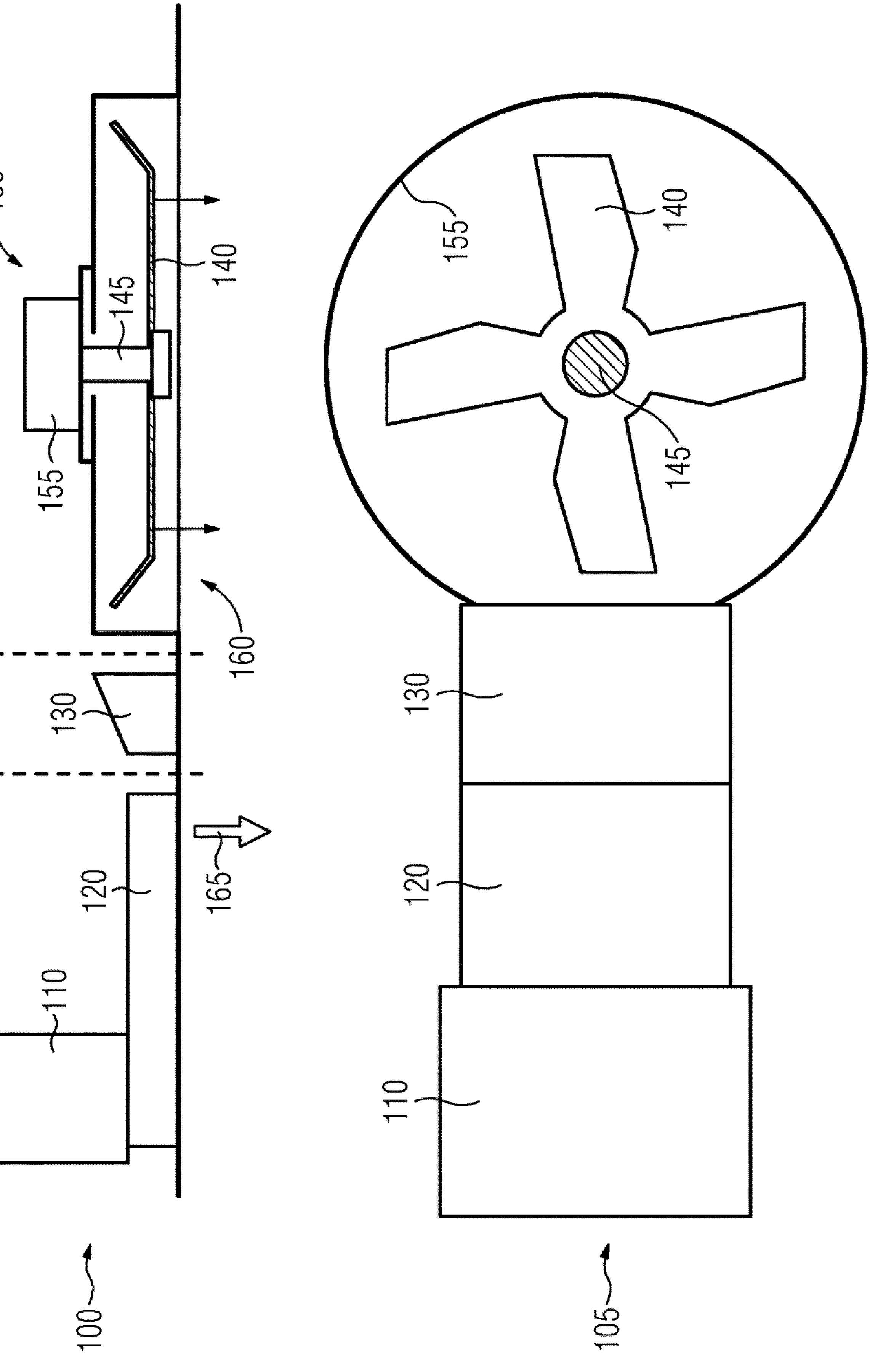
15. Microwave oven according to claim 14,
- wherein the microwave oven comprises a cooking cavity (310) for the items to be applied by the microwaves,
- wherein the cooking cavity (310) is limited at its upper side by a ceiling (320),
- wherein at least one (124) of the side surfaces (121 - 124) of the rectangular or of at least substantially rectangular waveguide (120) is formed by the ceiling (320),
- whereas preferably the ceiling (320) of the cooking cavity (310) is of at least slightly concave or convex shape, so that also the at least one (124) of the side surfaces (121 -124) of the waveguide (120) has an at least slightly concave or convex shape.

16. Microwave oven (300) according to claim 14 or 15, wherein the cylindrical corrugated horn antenna (203, 210) is mounted next to a ceiling (320) of a cooking cavity (310).

17. Method for manufacturing a microwave oven (300) comprising at least the following steps:
    - mounting a magnetron (400),
    - mounting a rectangular or at least substantially rectangular waveguide (410),
    - mounting a corrugated cylindrical horn antenna (203, 210), inside the housing of the microwave oven (300).

18. Method for manufacturing a microwave oven (300), further comprising:
    mounting (430) a cylindrical waveguide (203) coupled next to the rectangular or at least substantially rectangular waveguide (120).

19. Method for heating food at least comprising:
    - generating microwave energy,
    - feeding the microwave energy to a rectangular waveguide (120),
    - exciting a cylindrical waveguide (203) with microwaves emanated from the rectangular or at least substantially rectangular waveguide (110),
    - emanating the microwave energy from a corrugated part of a cylindrical horn antenna (203) onto the food.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130
120
110
105

FIG 1

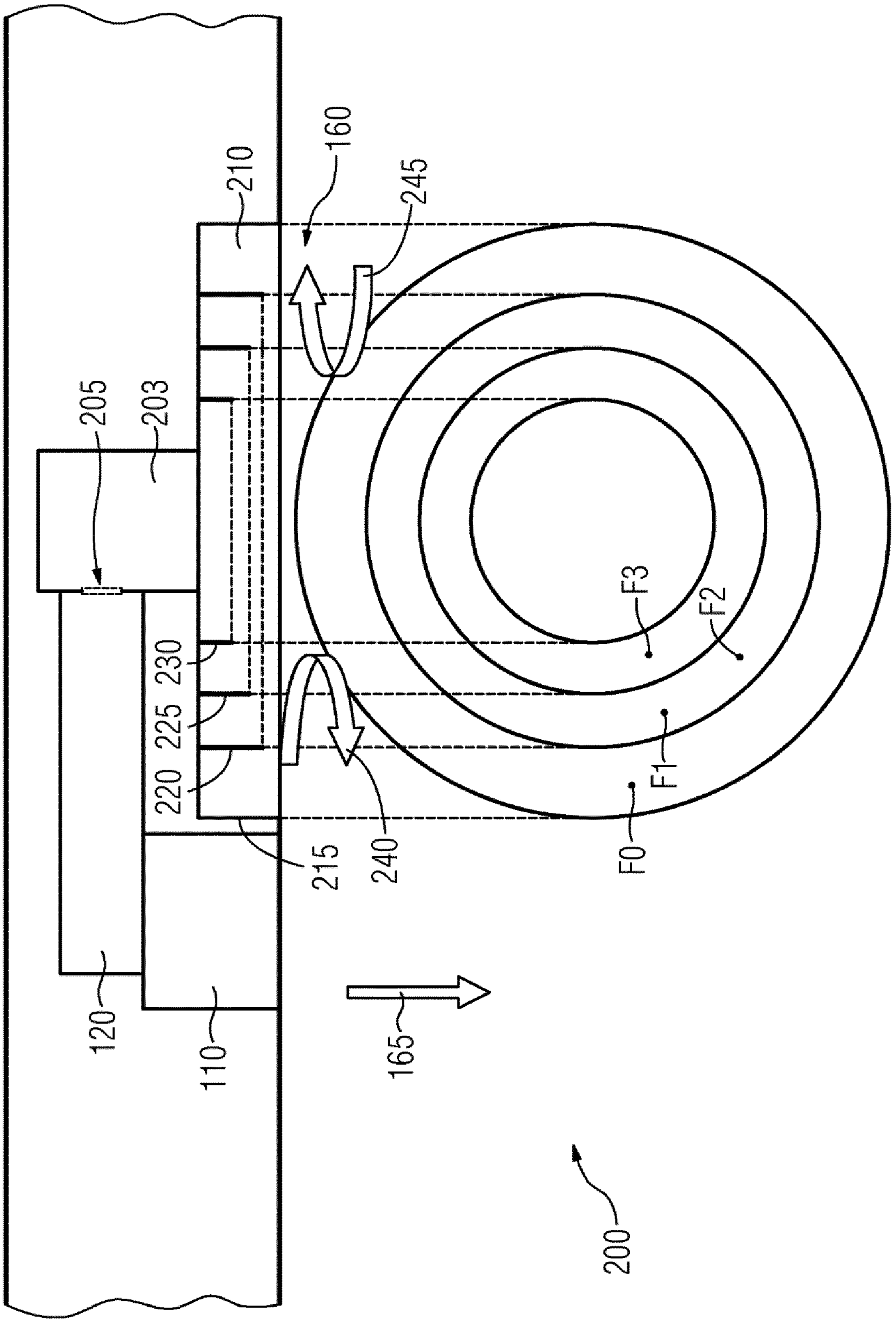

160
210
245
205
203
230
225
220
215
240
F0
F1
F2
F3
120
110
165
200

FIG 2

FIG 3

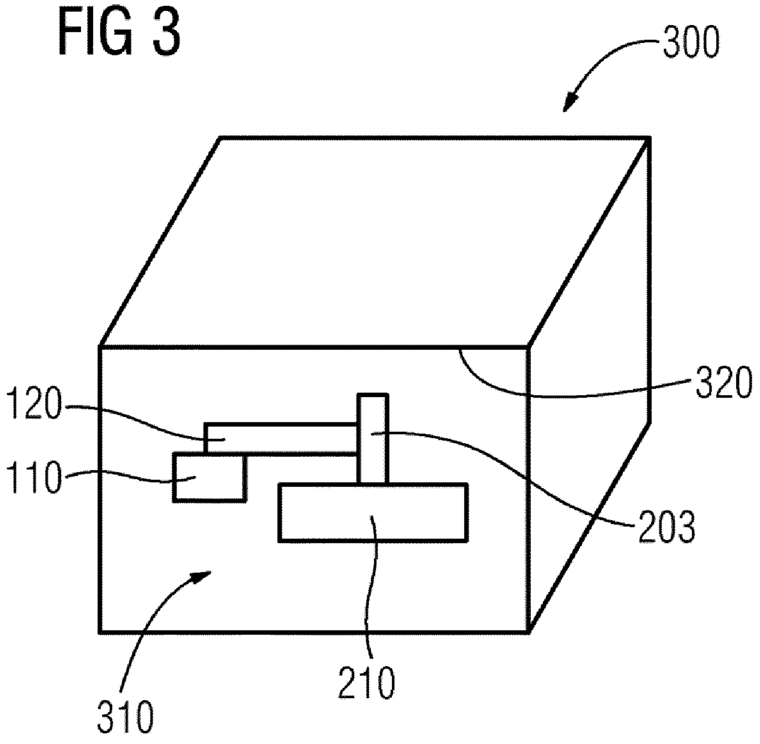


FIG 4

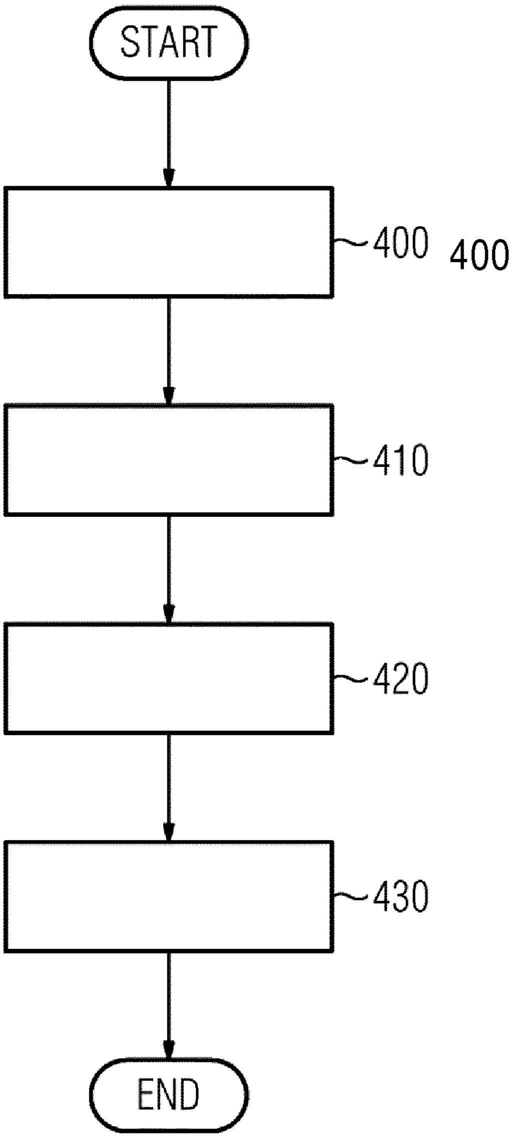


FIG 5

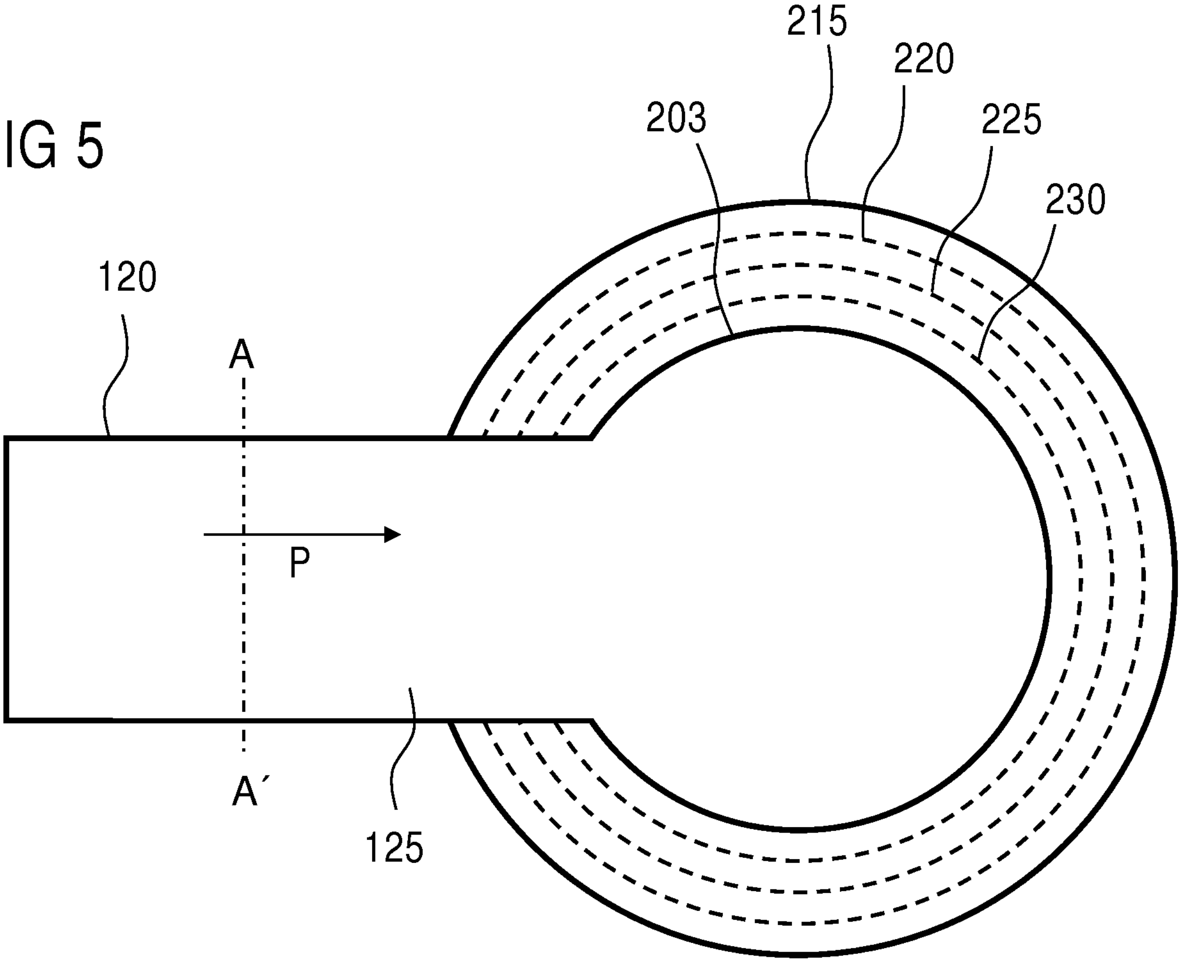
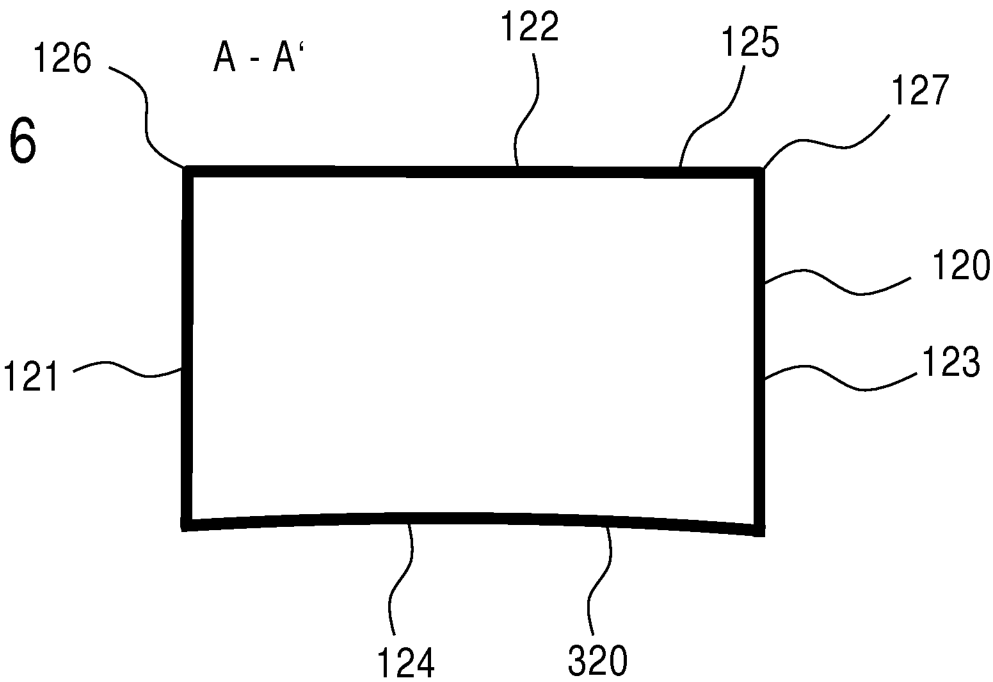

215
220
203
225
230
120
A
P
A´
125

FIG 6


126
A - A‘
122
125
127
120
121
123
124
320

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/052497

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B6/70 H01Q13/02 H05B6/72
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/068275 A1 (HUANG CHIH-YUNG [TW] ET AL) 20 March 2008 (2008-03-20) paragraph [0024] - paragraph [0026]; figures 1A,1B paragraph [0029] - paragraph [0030]; figures 2A,2B	1-19
X	US 5 486 839 A (RODEFFER CHARLES E [US] ET AL) 23 January 1996 (1996-01-23) cited in the application column 3, line 30 - line 40; figures 2,3	1,7
A	WO 2013/018358 A1 (PANASONIC CORP [JP]; SADAHIRA MASAFUMI; HOSOKAWA DAISUKE; YOSHINO KOJI) 7 February 2013 (2013-02-07) the whole document	1-19

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 March 2015	31/03/2015

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 425 174 A1 (CIM LAMBDA INT SARL [FR] CIM LAMBDA INT SARL) 30 November 1979 (1979-11-30) the whole document -----	1-19
A	US 5 434 585 A (HARRIS JAMES M [US]) 18 July 1995 (1995-07-18) the whole document -----	1-19

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/052497

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 2008068275	A1	20-03-2008	TW	I301337	B	21-09-2008
			US	2008068275	A1	20-03-2008
US 5486839	A	23-01-1996	AU	3242295	A	04-03-1996
			CA	2195011	A1	15-02-1996
			US	5486839	A	23-01-1996
			WO	9604692	A1	15-02-1996
WO 2013018358	A1	07-02-2013	CN	103718644	A	09-04-2014
			EP	2741574	A1	11-06-2014
			US	2014166645	A1	19-06-2014
			WO	2013018358	A1	07-02-2013
FR 2425174	A1	30-11-1979	NONE			
US 5434585	A	18-07-1995	NONE			