(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 040 623 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.07.2016 Bulletin 2016/27

(51) Int Cl.:
F24C 7/06 *(2006.01)* ***F24C 7/04*** *(2006.01)*

(21) Application number: **15201271.2**

(22) Date of filing: **18.12.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **31.12.2014 IT TO20141130**

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(54) **METHOD FOR HEATING A MUFFLE, AND ASSOCIATED OVEN**

(57) The invention relates to a method for heating a muffle (1) of an oven or a similar household appliance, wherein the heating element employed is a heating wire (15) made of carbon, carbon fiber or the like, which can provide thermal energy by electric dissipation and infrared irradiation within the muffle heating temperature range.

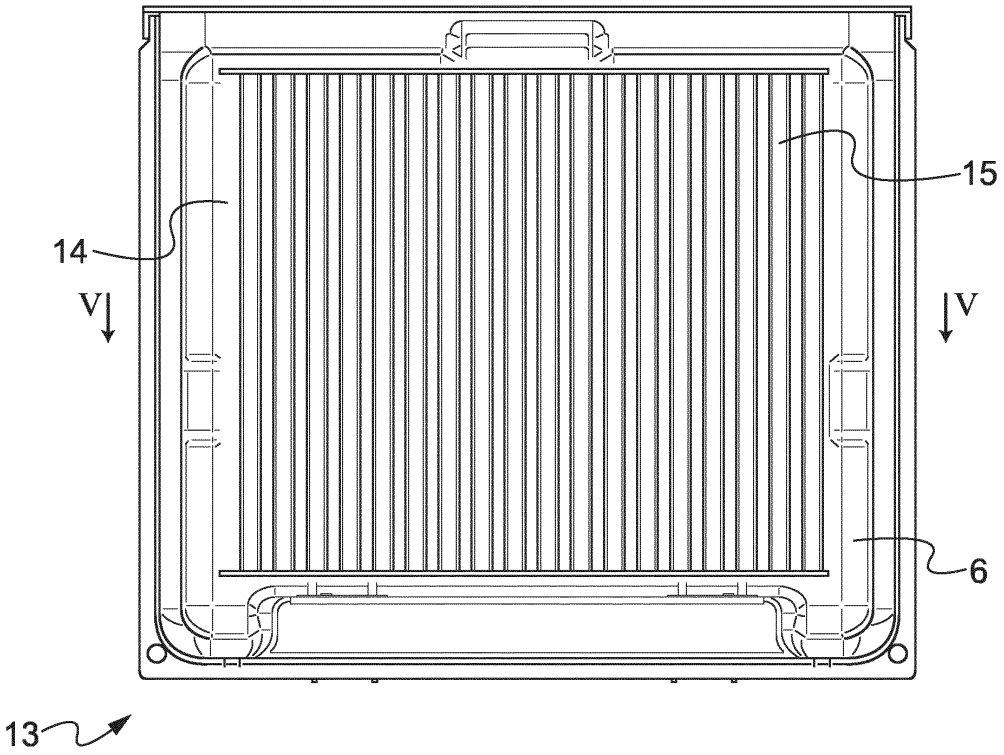

Fig. 4

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Description

[0001] The present invention relates to a heating method particularly intended for household appliances, as well as to an associated oven made accordingly.

[0002] The latter may be an embedded oven, i.e. a self-standing household appliance which is inserted into a piece of furniture, or it may be a part of a bigger household appliance, such as a gas or electric cooker, equipped with burners, heating plates and the like.

[0003] The ovens considered herein are of the electrically heated muffle type; as is known, these ovens have a hollow body, which forms the muffle and which is substantially cubical in shape or anyway shaped like a parallelepipedon or the like, circumscribing a cooking chamber where food to be heated is introduced.

[0004] The muffle is closed at the front by the oven door, and is in its turn inserted into a compartment formed in a cabinet, for embedded ovens, or into the structure of a cooking range, depending on the application; in the compartment, the muffle may be thermally insulated (e.g. with mineral wool), and the heat thereof may be removed by ventilation.

[0005] For heating the muffle, electric resistors are used which may be arranged outside and/or inside of it; the present invention applies to both solutions, even though it is preferably applied to the latter type, i.e. resistors arranged inside the muffle.

[0006] As is known, regulations pertaining to the energy consumption of household appliances are nowadays rather restrictive; manufacturers are thus compelled to constantly and systematically look for new technical solutions leading to reduced or anyway limited energy consumption.

[0007] For this reason, some ovens are equipped with cooking programs optimized according to the user's requests; for example, the operating cycle of the oven will be different for baking a cake or cooking a roast: this allows optimizing the power-on times of the electric resistors and the control of the circulation of the heated air in the chamber.

[0008] In fact, in an oven muffle heating mainly occurs through heat provided by electric resistors, whether arranged inside or outside the muffle.

[0009] Resistors may have different shapes and/or dimensions depending on the application, but they are usually configured as coil-bent bars containing the actual electric resistor (a filament made of tungsten or alloys thereof or another appropriate material), buried into refractory powders based on zirconium, silicon or the like.

[0010] This type of resistor has proven to be effective and reliable over time, although it has a few drawbacks.

[0011] In fact, the thermal inertia and the time necessary to reach the required temperature values are not always suited to the various needs: as can be easily understood, the cooking cycles of an oven may require different times and operating modes even when the respective resistors are substantially similar from a structural viewpoint.

[0012] For example, sometimes it is advantageous to have the heat come prevalently from above (e.g. for browning the top part of a roast or a cake), and sometimes it is better to provide more uniform heating by using resistors arranged at the bottom or at the sides.

[0013] Furthermore, as far as consumption is concerned, the resistors known in the art do not appear to be an optimal solution, also because they are rather rigid both from a structural viewpoint, due to the above-mentioned configuration, and from a functional viewpoint, since such a configuration does not allow them to be easily arranged in different places of the oven or in differently sized ovens, so that they can be adapted to particular contingent situations.

[0014] The present invention aims at improving this state of the art; in other words, the technical problem at the basis of the invention is to provide a new method for heating an oven, with such operating features that allow overcoming the above-mentioned limitations of the prior art.

[0015] The idea that solves this problem is to use electric resistors which are different from those known in the art, and which consume less energy and/or are equally or more efficient than the latter.

[0016] Within the scope of this general principle, the solution found by the Applicant is to use electric resistors based on non-metallic materials; among such materials, composite fibers based on carbon, boron or the like are particularly suitable.

[0017] In this respect, it must be pointed out that the Applicant knows that these fibers are used for civil heating applications and also for parts of machinery, such as, for example, the defrosting systems for aircraft wings described in the American patent US 4,737,618.

[0018] However, the Applicant does not know of any application to household appliances, in particular for oven heating purposes.

[0019] According to the invention, it is possible to create heating systems that are functionally flexible, so that they can be easily adapted to various ovens in order to reduce their energy consumption and improve their thermal efficiency.

[0020] The features of the invention are specifically set out in the claims appended to this description; all such features will become more apparent in the light of the following description of a few embodiments shown in the annexed drawings, wherein:

- Fig. 1 is an axonometric view of a muffle of an oven to which the heating according to the invention has been applied;
- Fig. 2 is a front view of the muffle of Fig. 1;
- Fig. 3 is a view of the muffle of Fig. 1 and of the front panel of the associated oven, with a part thereof removed;
- Fig. 4 shows a first detail of the muffle of the preceding figures;

- Fig. 5 is a sectional view along line V-V of Fig. 4;
- Fig. 6 shows a second detail of the muffle of the preceding figures;
- Fig. 7 is a sectional view of a variant of a detail of the muffle of the preceding figures;
- Fig. 8 is an axonometric view of a variant of the muffle according to the invention;
- Fig. 9 is a sectional view of a detail of the muffle of Fig. 8.

[0021] With reference to the above-listed drawings, particularly to Figures 1-5, there is shown an application of the heating of the invention to an oven muffle, designated as a whole as 1.

[0022] Prior to describing this and other examples of the invention, it is worth pointing out that in this description reference will essentially be made to those elements which are necessary or useful for understanding the invention and the features thereof, neglecting for brevity the remaining parts of the household appliance, i.e. the oven, for further details of which reference should be made to the technical teachings known in the art. For this reason, reference should be made to the broad technical and patent literature on this matter, as well as to the household appliances manufactured by the present Applicant.

[0023] Furthermore, any special shape, structure or feature described herein may be appropriately combined in one or more embodiments, even different from those illustrated and/or described herein, and the references used herein only aim at better clarity and convenience, without limiting the protection scope of the invention.

[0024] As a consequence, definitions such as "embodiment" and the like indicate in this description that at least one element, configuration, structure or feature described in relation to a specific embodiment or example is comprised in at least one of the possible implementations of the invention; therefore, phrases such as "in one embodiment" and the like, which may occur several times in this description, will not necessarily refer to the same embodiment or implementation of the invention, but may refer to more than one.

[0025] After this necessary preamble, the muffle 1 comprises a cooking cavity or chamber 2 delimited by a pair of side walls 3 and 4, a back wall 5, a top wall 6 and a bottom wall 7.

[0026] The walls 3-7 of the muffle 1 can be made by using any method known in the art, e.g. by sheet metal pressing, bending or the like; however, as will become apparent below, other materials can be used as well, particularly those having good infrared emission properties.

[0027] Furthermore, according to some possible embodiments, the side walls 3 and 4, the back wall 5, the top wall 6 and the bottom wall 7 are made as one piece (e.g. in pairs, triples, etc.) and are connected through junction means (e.g. welding, clinching, riveting, or the like), so as to prevent fumes, odours or the like from exiting or leaking out. According to this embodiment of the invention, the inner face of the walls 3-7 of the muffle, i.e. the one towards the cooking chamber 2, is coated with carbon.

[0028] Several solutions may be used for this purpose; one is the application of a coating based on the so-called carbon nanotubes (see https://en.wikipedia.org/wiki/Carbon_nanotube), i.e. layers including nanometric carbon particles having a tubular allotropic shape (hence their name), and wherein said particles may have, among other things, good electroconductive characteristics.

[0029] The nanotube coating can be applied by means of any appropriate technique, e.g. by physical or chemical deposition (also known as PVD - Physical Vapour Deposition - or CVD - Chemical Vapour Deposition) of the nanometric particles, or by applying paints in which such particles have been dispersed (single-component or two-component paints suitable for this purpose are produced by German company BYK-Chemie under the commercial name Bayhydrol, Worleesol).

[0030] The thickness of the carbon coating layer of the walls may vary as a function of a number of parameters, such as the shape and dimensions of the muffle 1, the temperatures of the oven for which it is intended (e.g. normal or pyrolytic ovens), layer type and application (PVD, CVD, paint, etc.); the thickness is however preferably in the range of 1 to 10 millimetres.

[0031] As an alternative, the inner walls 3-7 of the muffle 1 may be covered with panels made of, or coated with, carbon in the form of the above-mentioned nanotubes o other allotropic forms, such as graphite, and mechanically secured to the walls themselves (e.g. by means of screws, brackets, squares or the like).

[0032] In this case as well, the thickness of the carbon and of the associated panel may vary depending on the above-mentioned factors.

[0033] As aforesaid, other elements of the oven are arranged outside the muffle 1, which are just outlined in Figure 3 for simplicity's sake, such as, for example, insulating material (mineral wool, synthetic foam and the like), cooling (ventilation) means, curtain panels and the like; they should nevertheless be considered to be included in the ovens made in accordance with the invention.

[0034] In order to better illustrate this situation, Figures 2 and 3 also show a part of the frame T that constitutes the front panel of the oven, which houses the control knobs M, the user interface (temperature indicators, warning lamps, buttons, etc.), and where the oven door (not shown) is inserted.

[0035] On the side walls 3, 4 there are the usual guides 8 for supporting grates, dripping pans and anything which may be used for cooking food; the grates, dripping pans, etc. are not shown in order to make the drawings simpler and clearer.

[0036] On the back wall 5 there is a grid 9 for the passage of the ventilation air blown by the fan 10, which

causes the air to circulate within the cooking chamber 2 so that, along its path, it will lap the top wall 6, where a heating device 13 is located.

[0037] This ensures a more uniform heat distribution inside the cooking chamber 2.

[0038] The heating device 13 comprises a resistor 15 consisting of a heating wire made of carbon, wound around a support 14; heating wires suitable for the present applications are commercially available, for example, from company Thermal Technology in Italy or from companies Senphus and CIT Solution in China (Hong Kong).

[0039] The gauge of the wire 15 may vary depending on the amount of heat to be produced, on its length, and on the power voltage; generally the gauge of the heating wire 15 will be approx. 1-2 mm^2, while its length will depend on the dimensions of the oven and on the winding pitch of the wire on the support 14. It must also be pointed out that the latter may support two or more heating wires 15 powered in parallel, so that the length thereof will also depend on their number.

[0040] For example, in the case of a muffle wherein the top wall 6 is substantially square with a 0.5m side, heating wires may be employed of the order of a few tens of metres, wound with a 1-2mm pitch.

[0041] In this regard, it must be pointed out that the support plate 14 of the heating wire 15 is preferably of the irradiating type; to this end, it is made of an appropriate material, i.e. a material that can provide maximum irradiation of thermal radiations (i.e. radiations comprised in the range from infrared to ultraviolet, with wavelengths of 10^{-1} to 10^2 μm) in the temperature range of 80 °C to 150°C.

[0042] Suitable materials for the support plate 14 can thus be some metals (preferably with treated surfaces), such as, for example, anodized aluminium or alloys thereof, nickel, and also non-metallic materials such as mica, ceramic materials, glassy materials, or even synthetic materials.

[0043] Furthermore, in accordance with a preferred embodiment, also the plate 14 is coated with, or made of, carbon, as previously explained with reference to the walls 3-7; for brevity, reference should be made to the explanations of the making of the coating or structure of the plate 14, which in this way will be able to absorb and emit radiations in the infrared range for the working temperatures of the oven.

[0044] The best choice of the material for the plate 14 will depend on several factors, such as the dimensions and weight of the heating device 13 (also related to the thermal exchange with the air circulating in the muffle 1), its shape (the device 13 may also have a cylindrical geometry), and the like.

[0045] The heating device 13 is electrically supplied; to this end, in this example it is connected, through the terminals 16, 17, to the system of the oven where the muffle 1 is installed.

[0046] According to the embodiment shown in Figures 1-6, a protection sheet 20 is associated with the bottom wall 7 of the muffle 1, which sheet is transparent to infrared rays; for this purpose, the sheet 20 is made of quartz or another equivalent material: thus, the carbon-coated surface of the wall 7 can be protected against fouling or deposits (e.g. fats or the like) released by the food being cooked in the oven.

[0047] The muffle 1 of the oven can be controlled by a user just like a normal oven, i.e. by operating one of the knobs M available on the front panel.

[0048] The heating wire 15 will then be electrically supplied, heating up to temperatures of 120-200 °C; thanks to its reduced thermal inertia, the heating wire 15 will promptly reach the operating temperature, and the heat produced by it will be diffused in the cooking chamber 2 by irradiation and convection in variable proportions, depending on the operating step in execution.

[0049] In fact, as far as the former is concerned, it must be remarked that the carbon that the resistor wire 15 is made of is characterized by good infrared irradiation within the above-mentioned range of operating temperatures.

[0050] Nonetheless, it also has the heat dissipation properties which are typical of electric resistors; therefore, the radiating and resistive heating components can be controlled in such a way as to achieve the best efficiency of the muffle 1.

[0051] To this end, the heat electrically dissipated by the carbon wire 15 is removed by convection and diffused throughout the cooking chamber 2 by means of forced air circulation provided by the fan 10, which preferably creates an air flow that will lap the upper part of the chamber 2, where the heating wire 15 is located.

[0052] Note that the air will also be directed into the interspace defined between the top wall 6 and the plate 14 that supports the heating wire 15, as shown in Figure 5, thus maximizing the thermal exchange by convection.

[0053] This kind of operation is appropriate when heating begins, i.e. when the walls 3-7 of the cooking chamber 2 are still cold.

[0054] As they heat up, they will start irradiating thermal energy in the form of infrared radiations, thanks to the carbon layer applied onto them.

[0055] It follows that the heat dissipative thermal component provided by the heating wire 15 can be reduced or adapted as a function of the radiating heat emitted by the walls 3-7 of the muffle 1.

[0056] This advantageous effect adds up to the effect obtained by using carbon-fibre resistors as a heating wire 15, which can be supplied with less current, the other conditions being equal, than a normal resistor (made of tungsten or the like) in order to reach the operating temperatures.

[0057] It follows therefore that the overall the electric energy consumption required for heating the muffle 1 will be reduced, in that the electric resistor 15 is not mainly used for generating heat by electric dissipation, as in known resistors, but it also allows generating a significant

radiating thermal component within the range of operating temperatures.

[0058] The effect of this infrared radiating component is synergically amplified by the walls 3-7 of the cooking chamber, which for this reason are advantageously associated with a carbon layer, so that they will also contribute to irradiation.

[0059] In this respect, it must also be pointed out that the heating wire 15, or the heating wires if more than one, as previously explained, are arranged on a large surface in order to promote the above-discussed thermal effects.

[0060] In fact, by increasing the exchange area as in this case, the heating wire 15 can be kept at temperatures lower than those of a traditional resistor, the amount of transferred heat being equal, since what is important is the total heat provided. This aspect also contributes to reducing the energy consumption.

[0061] Of course, the invention may be subject to variations with respect to the description provided so far; it is in fact understandable that, within the scope of the general principle of exploiting both the heat provided by electric dissipation by a resistor and the radiating heat provided by the same resistor, different solutions can be conceived, whether alternative or combined with the one referred to above.

[0062] For example, with reference to Figure 7, wherein some elements which are structurally or functionally equivalent to those described above are designated by the same reference numerals with the addition of an apostrophe, there is shown the cross-section of the bottom wall 7 of the muffle, to which a heating system is applied which consists of a carbon wire 15' supported by a plate 14'.

[0063] These elements are analogous to those already described, and therefore reference should be made, for the sake of brevity, to the above explanations; in this respect, it must however be added that the heating carbon wire 15 or 15' may be associated with either or both of the top wall 6 and bottom wall 7 of the muffle 1, so that the effects already explained will still apply, though with appropriate adaptations.

[0064] For example, in order to promote air circulation and thermal exchange with the lower heating wire 14', the protection sheet 20 may be removed or anyway equipped with openings facilitating air circulation.

[0065] In this regard, according to a further possible variation of the muffle 1, the sheet 20 may also be used as a cooking or heating plate.

[0066] For this purpose, it may be made of a ceramic or glass-ceramic material, so that the sheet 20 will also heat up by absorbing infrared radiations.

[0067] It must also be pointed out that the heating system with a heating carbon wire 15 arranged inside the cooking chamber 2 does not exclude the application of other heating means outside the same; this is the case, for example, shown in Figures 8 and 9, which illustrate the application of a second heating device 13" in accordance with the invention on the outside of the bottom wall 7 of the muffle 1.

[0068] In this case, as can be seen, under the muffle there is a tray 23", which is secured to the bottom wall 7 by means of screws, brackets or another appropriate system (e.g. welding or the like), and which circumscribes a heating wire 15" supported by a plate 14"; these latter items are analogous to those discussed in the previous description, to which reference should be made for the sake of brevity (in Figure 8 the heating wire 15" is drawn with a dashed line).

[0069] In the space delimited by the tray 23"air can circulate, as indicated by the arrows in Figure 9, which may lap the other walls 3-7 of the muffle in order to heat them up, or may be delivered into the cooking chamber 2 through the aperture 9 in the back wall 5.

[0070] Said walls 3-7 can thus be heated, promoting the emission of radiating heat thanks to their carbon coating.

[0071] Finally, according to another possible variant, the heating carbon element 15, 15' or 15" is provided in the form of a panel as opposed to a wire; said heating element may be made by deposition or by using another appropriate technique, as explained with reference to the coating layer of the walls 3-7.

[0072] All of these variants will still fall within the scope of the following claims.

Claims

1. Method for heating a muffle (1) of an oven or a similar household appliance, **characterized in that** it uses, as a heating element, at least one resistive element (15; 15'; 15") made of a material suitable for providing thermal energy by electric dissipation and irradiation in the infrared range, for the muffle heating temperatures.

2. Method according to claim 1, wherein the resistive element (15; 15'; 15") is made of carbon, carbon fiber or the like.

3. Method according to claims 1 or 2, wherein said at least one resistive element (15; 15'; 15") is applied on a wall (3-7) of the muffle (1).

4. Method according to any one of the preceding claims, wherein the heating element (15; 15'; 15") operates at temperatures below 230 °C.

5. Oven muffle, comprising a plurality of walls (3-7) circumscribing a cooking chamber (2), heating means (13; 13'; 13") for heating the cooking chamber (2), **characterized in that** the heating means comprise a resistive element (15; 15'; 15") made of carbon, carbon fiber or the like, suitable for providing heat by electric dissipation and infrared irradiation.

6. Muffle according to claim 5, wherein the resistive heating element (15; 15'; 15") is arranged inside and/or outside the cooking chamber (2).

7. Muffle according to claims 5 or 6, wherein the resistive heating element comprises a wire (15; 15'; 15") made of carbon, carbon fiber or the like, which is supported by a plate (14; 14'; 14") substantially facing one of the walls (3-7) that circumscribe the cooking chamber (2).

8. Muffle according to claim 6, comprising ventilation means adapted to cause air to circulate between the plate (14; 14'; 14") and the wall (3-7) opposite thereto.

9. Household appliance according to claims 7 or 8, wherein the plate (14; 14'; 14") is of the irradiating type and is adapted to irradiate within the infrared range at muffle heating temperatures.

10. Muffle according to any one of claims 5 to 9, wherein at least one of the walls (3-7) is coated or associated with a layer of carbon, carbon fiber or the like, so as to emit heat by infrared irradiation.

11. Muffle according to any one of claims 5 to 10, comprising a sheet (20) for protecting a respective wall (3-7), made of a material transparent to infrared radiations.

12. Muffle according to any one of claims 5 to 11, comprising a sheet (20) juxtaposed to the bottom wall (7), made of a material suitable for absorbing infrared radiations, thereby getting heated.

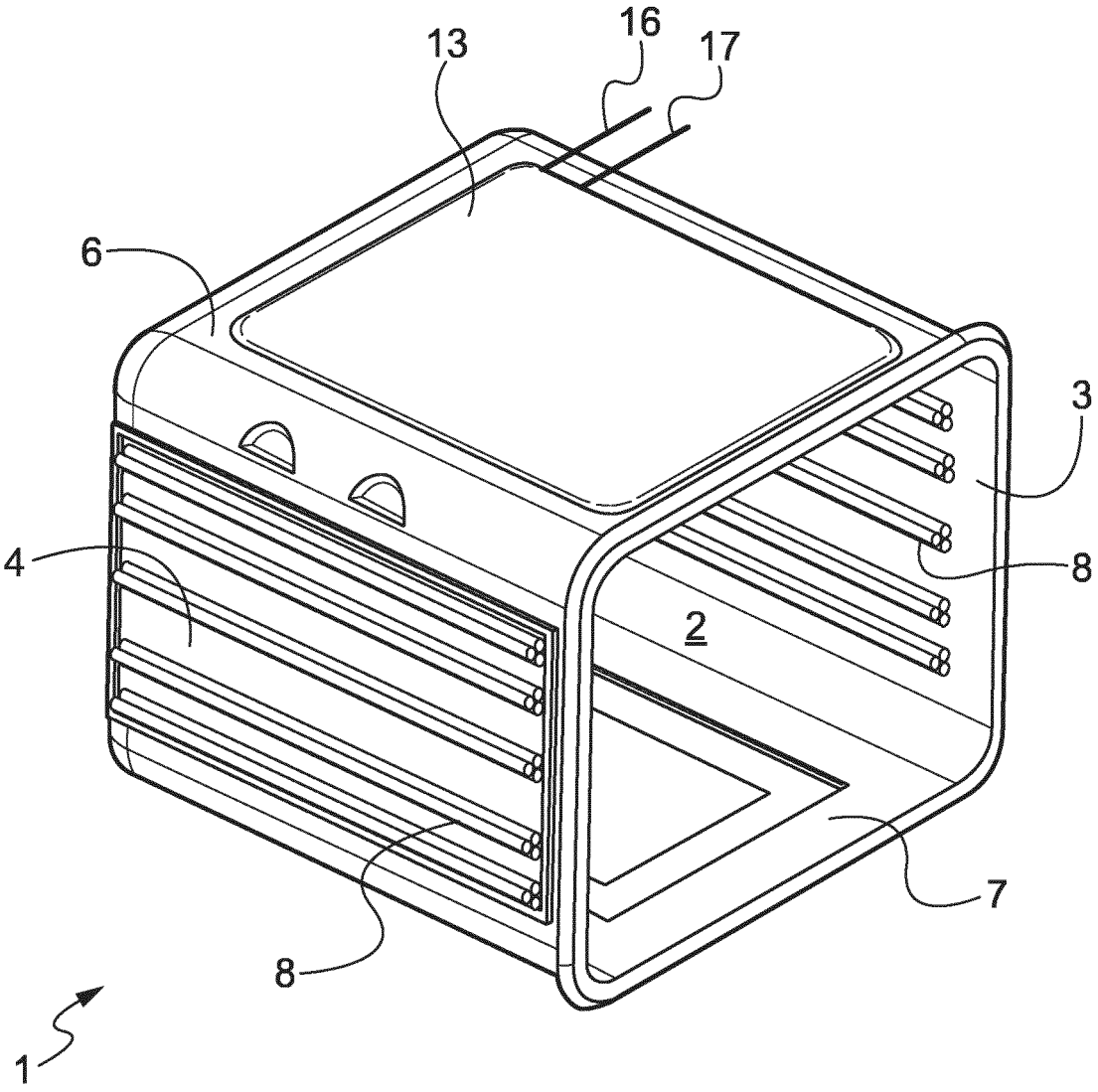

Fig. 1

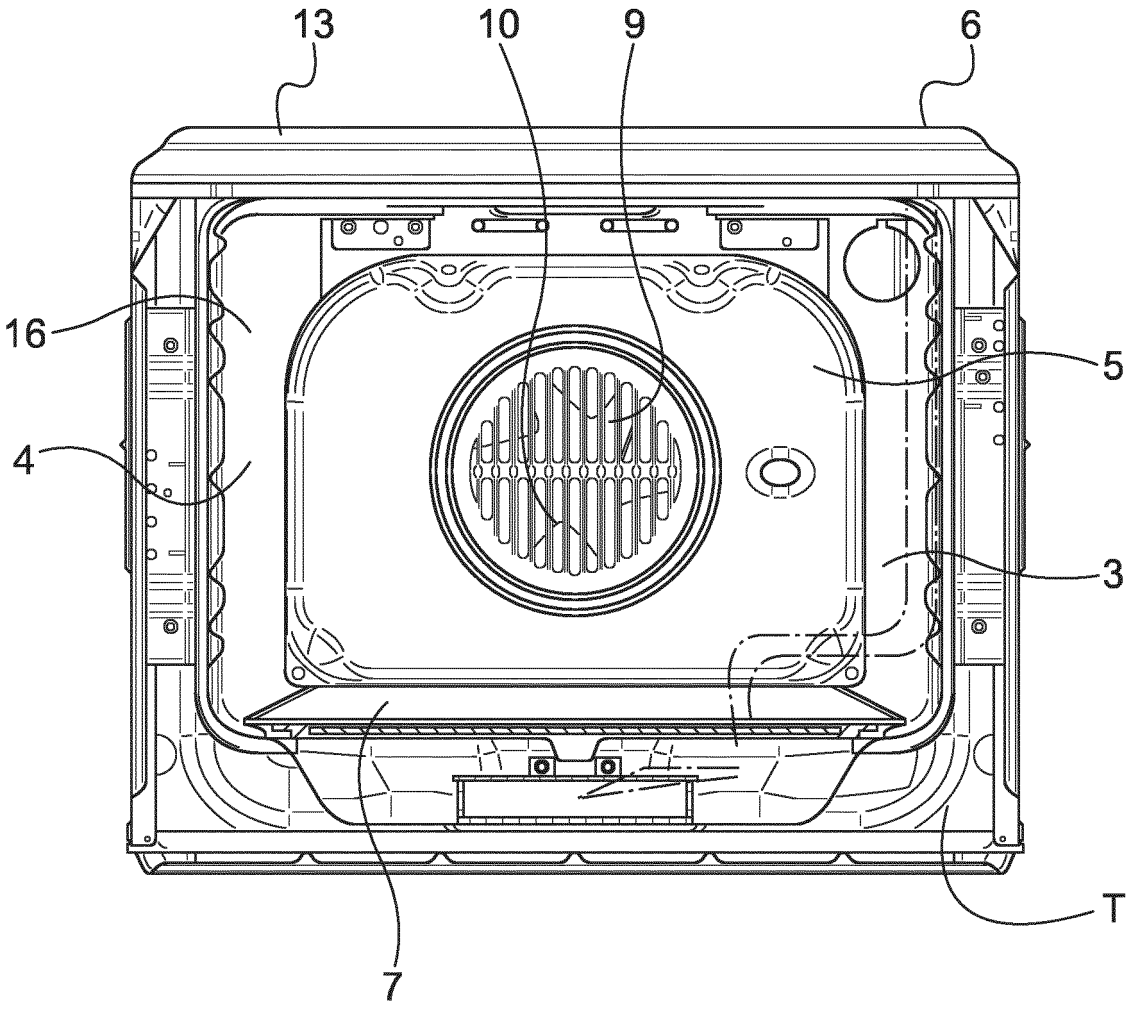

Fig. 2

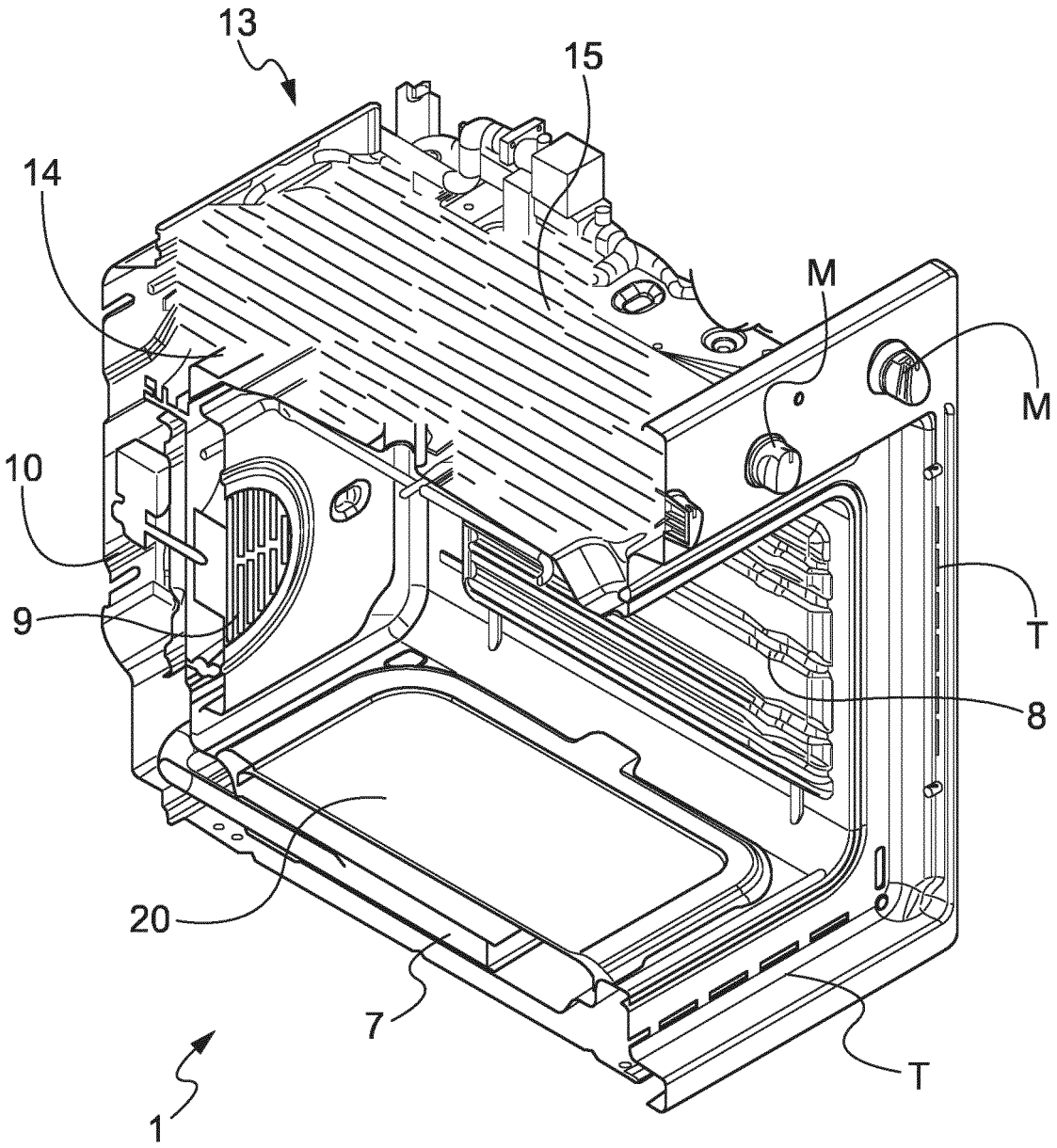

Fig. 3

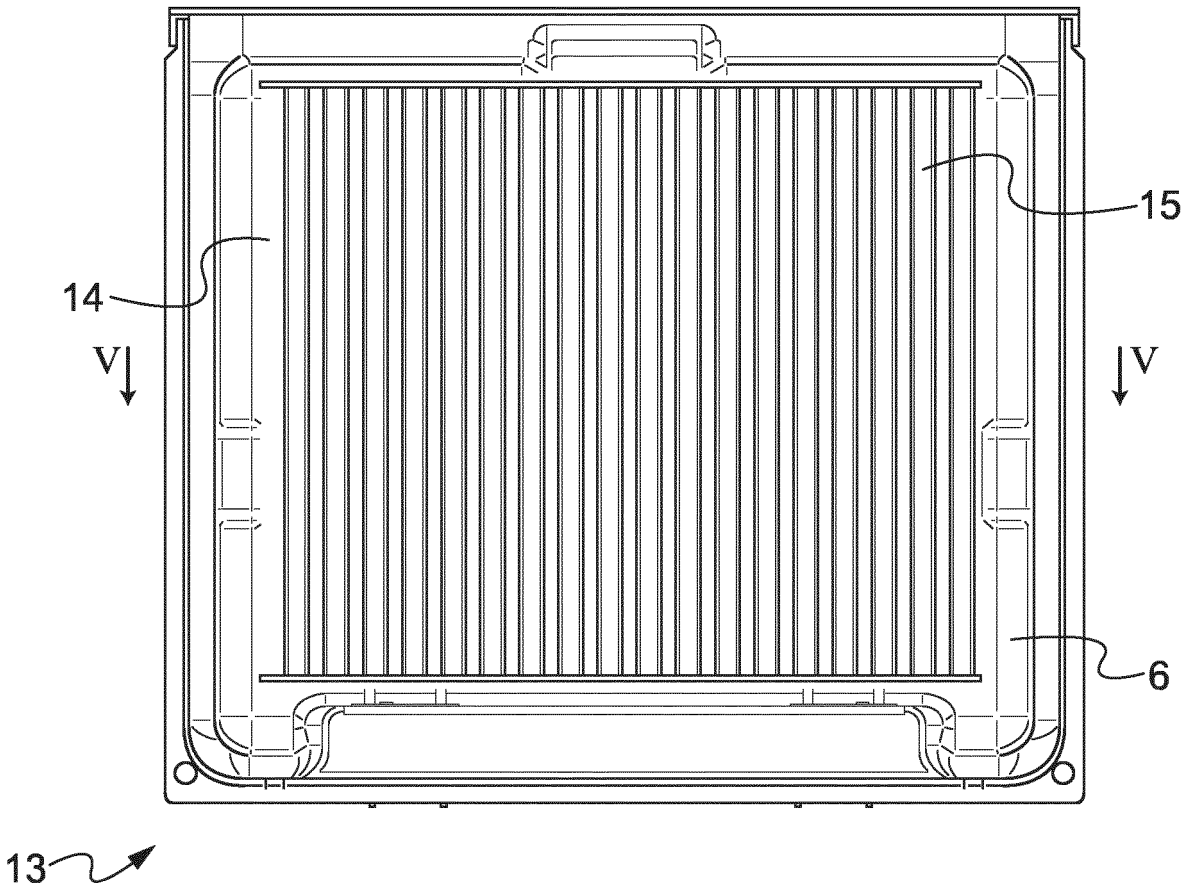

Fig. 4

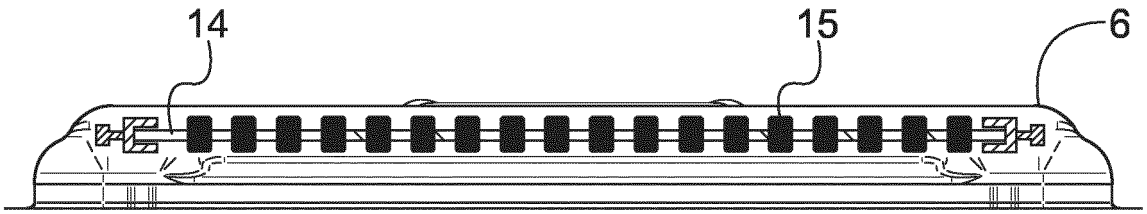

Fig. 5

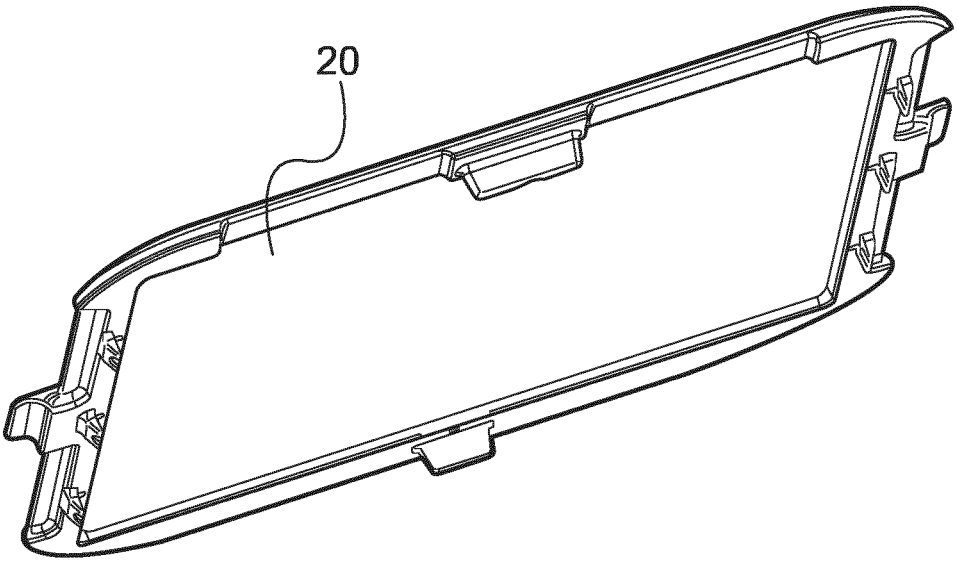

Fig. 6

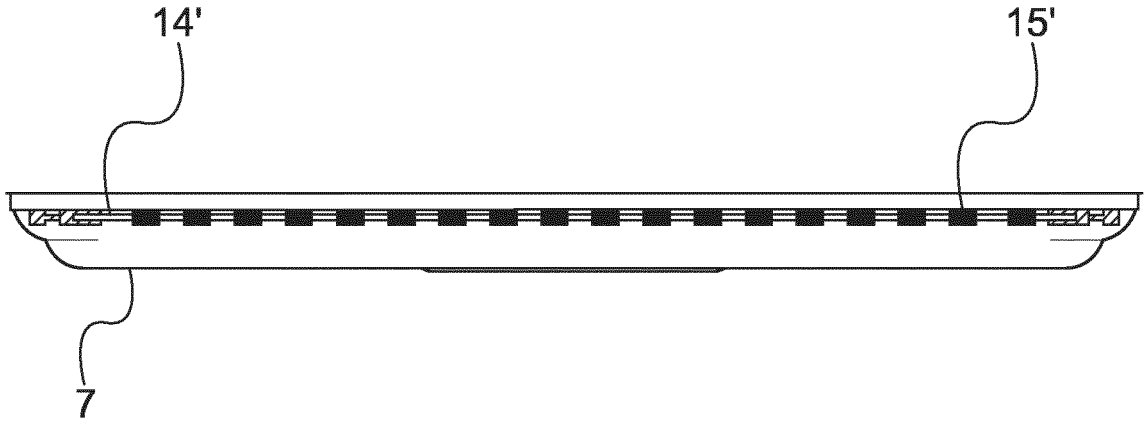

Fig. 7

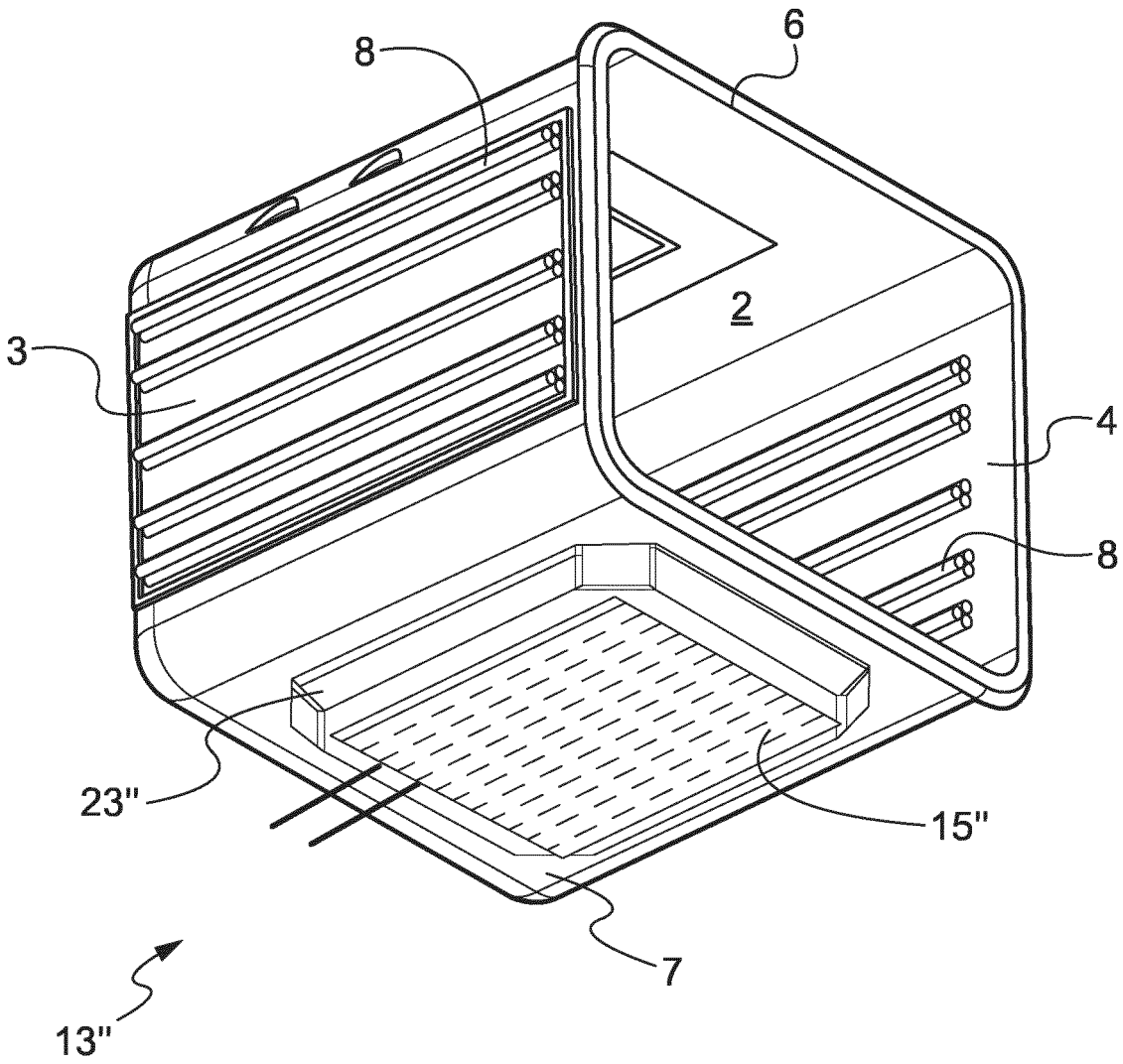

Fig. 8

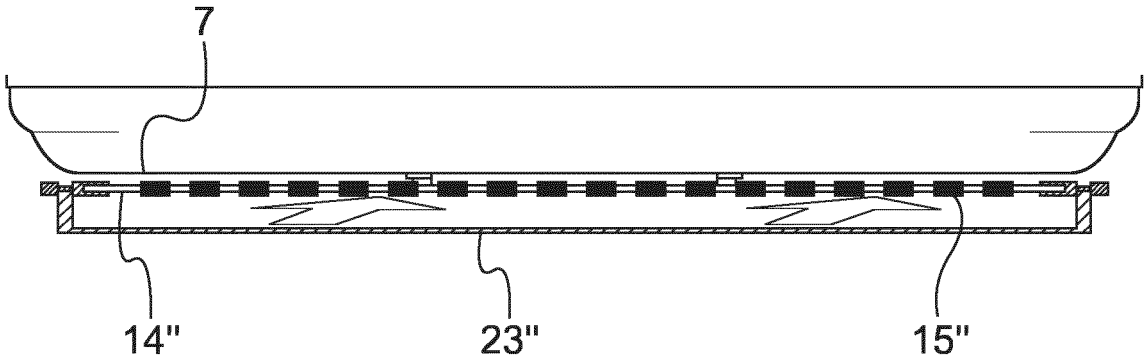

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 15 20 1271

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2013/334197 A1 (KIM HAGSOO [KR] ET AL) 19 December 2013 (2013-12-19) * paragraphs [0067], [0097]; claims 1,2; figures 3,4 *	1-7,9,11	INV. F24C7/06 F24C7/04
X	EP 2 161 508 A2 (LG ELECTRONICS INC [KR]) 10 March 2010 (2010-03-10) * paragraphs [0045], [0111]; claims 1,12; figures 3, 14,13 *	1-3,5-12	

TECHNICAL FIELDS SEARCHED (IPC)
F24C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 April 2016	Meyers, Jerry

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 20 1271

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29-04-2016

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