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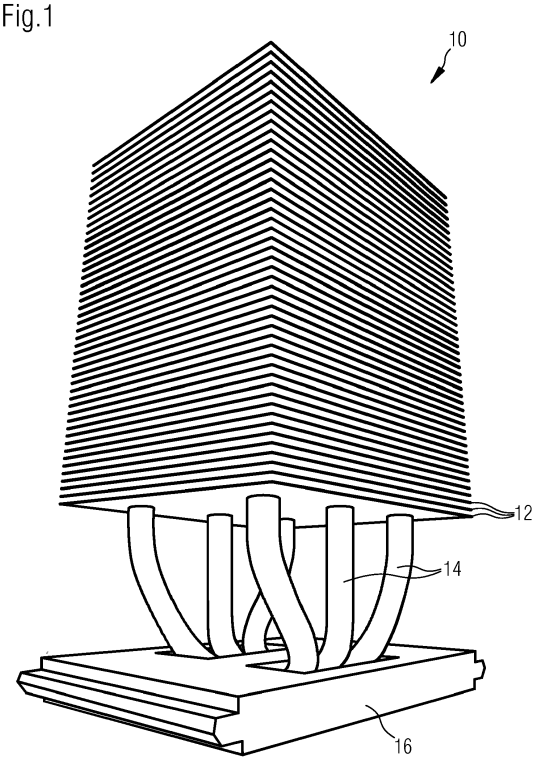
(54) HOUSEHOLD APPLIANCE WITH A CIRCUIT BOARD COMPRISING A POWER COMPONENT

(57) The present invention relates to a household appliance (20), particularly a cooking hob, more particularly an induction cooking hob, with a circuit board comprising a power component, in particular a semiconductor switch. The power component is in heat-conducting connection with a cooling device (10). The cooling device (10) comprises a primary cooling body (16) and a secondary cooling body (12), which are in heat-conducting connection with each other by means of at least one heat-conducting element (14) to that effect that the primary cooling body (16) is adapted to receive thermal energy from the power component which is heated up during its operation and to transmit the received thermal energy at least partially to the secondary cooling body (12).

Fig.1



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Description

[0001] The present invention relates to household appliance, particularly a cooking hob, more particularly an induction cooking hob, with a circuit board comprising a power component. The present invention further relates to an induction generator for an induction cooking hob.

[0002] In an induction cooking hob power components, e. g. induction generators, particularly semiconductor switches, are arranged. During their operation said induction generators generate high-frequency currents for the induction coils. Said induction coils provide the high-frequency magnetic induction field. The semiconductor switch, e.g. an insulated-gate bipolar transistor (IGBT), is heated up to about 100°C, so that cooling is required. Known cooling solutions provide an elongated aluminium cooling body, onto which the semiconductor switch is fixed, e.g. screwed. Further, a cooling fan provides a cooling air stream striving along the elongated cooling body.

[0003] However, this solution requires a relative long cooling body. The semiconductor switch is spaced from the cooling fan. The cooling of the semiconductor switch is not efficient. The thermal mass of the cooling body cannot be used efficiently. The thermal distribution along the longitudinal direction of the cooling body is uneven.

[0004] It is an object of the present invention to provide a cooling device for at least one semiconductor switch, which allows an efficient cooling of one or more power components, particularly semiconductor switches.

[0005] The object is achieved by the cooling device for at least one power component according to claim 1.

[0006] According to the present invention a household appliance, particularly a cooking hob, more particularly an induction cooking hob, includes a circuit board comprising a power component, in particular a semiconductor switch. The power component is in heat-conducting connection with a cooling device. The cooling device comprises a primary cooling body and a secondary cooling body. Said primary and secondary cooling bodies are in heat-conducting connection with each other by means of at least one heat-conducting element to that effect that the primary cooling body is adapted to receive thermal energy from the power component which is heated up during its operation and to transmit the received thermal energy at least partially to the secondary cooling body.

[0007] The main idea of the present invention is the split of a cooling means, which is used for cooling a power component during the operation thereof, into a primary component, i. e. a primary cooling body, and a secondary component, i. e. a secondary cooling body, wherein the primary cooling body is configured to assume a specific heat quantity for the short term and to transfer at least a relevant portion of the assumed heat quantity for its release, i. e. for its cooling down, to the secondary cooling body. Compared to the known solution, the solution according to the invention allows a smaller cooling body for the coupling of the power component, nonetheless with increased cooling effect.

[0008] In order to provide a specifically increased cooling result, at least the secondary cooling body, particularly also the primary cooling body, may be or may comprise a large-area surface or a large-scale wall or plate of the household appliance, which may be a metallic housing of the household appliance. Additionally or alternatively, a surface or a wall adjacent to the household appliance may serve the same purpose.

[0009] A preferred embodiment is characterized by a primary and/or a secondary cooling body, which comprise(s) a plurality of cooling fins forming a layered structure. With said plurality of cooling fins an increased surface of the cooling body is performed, in that an accelerated heat transfer from the cooling body to the ambient air is further eased. Preferably the cooling fins are arranged in parallel to each other.

[0010] Particularly, the layered structure formed by the cooling fins includes at least one hollow space, which is provided for receiving at least one power component, so that the power component is partially or completely enclosed by the cooling fins.

[0011] According to an embodiment, the cooling device, particularly the heat conducting element, comprises at least one heat transfer rod or tube penetrating at least a part of the cooling fins. In this case, at least a part of the heat transfer rods may be formed as at least one serpentine. The penetration is preferably realized in heat-conductive manner. A heat-transfer compound, preferably a heat-conducting paste, may support an exceptional heat transfer from the rod or tube to the cooling fins. The heat transfer rod or tube preferably extends perpendicular to said cooling fins.

[0012] A specifically preferred embodiment provides a heat-conducting element which is or comprises a heat pipe. This heat pipe solution may be a specific solution for the rod or tube. Said heat pipe allows a particularly accelerated heat transfer from the primary cooling body to the secondary cooling body. Hence, the primary cooling body is rapidly discharged from heat energy and prepared in the short run to assume a successive heat quantity from the power component.

[0013] The secondary cooling body may be configured to be arranged or arrangeable outside of the household appliance. This is advantageous when the secondary cooling body has to be or is favourably designed with dimensions not making an implementation within the household appliance possible. Preferably, the heat-conducting element is adaptable or adjustable to the installation conditions for the household appliance. The heat-conducting element may be movable, particularly slidable, as against the primary and/or the secondary cooling body.

[0014] According to an embodiment, the primary cooling body provides a thermal mass of said cooling device and/or is configured to serve as a heat buffer for heat power peaks. Said power peaks particularly appear as overshoots during an activation of the power component. At that moment of activating the power component, the

temperature of the primary cooling body is comparably low, maybe nearly at room temperature level, and prepared to assume a relevant magnitude of heat quantity, hence supporting the power component to stay as well at a temperature level which allows an efficient operation.

[0015] One specific embodiment of a household appliance comprises a plurality of secondary cooling bodies of smaller or reduced dimensions, which are connected by the heat-conducting element, particularly a first heat-conducting element, amongst themselves and the plurality of secondary cooling bodies is connected to the primary cooling body by means of the heat-conducting element, particularly a second heat-conducting element. Alternatively, the specific embodiment may be characterized in that each one of the plurality of secondary cooling bodies is individually connected to the primary cooling body by means of the heat-conducting element.

[0016] Further, the cooling fins may include a plurality of holes with engraved edges. Said holes with engraved edges increase the contact areas of the cooling fins on the one hand and act as distance elements between said cooling fins on the other hand. The cooling fins are particularly supported and spared in the outer portion by at least two holding elements.

[0017] Preferably, the cooling fins are equally spaced from each other. The equidistance of the cooling fins allows that the same air flow streams through each gap between the cooling fins.

[0018] Particularly, the cooling fins are made of material having high heat conductivity. The power components, e. g. the semiconductor switches, may be arranged on a carrier plate made of material with high thermal heat conductivity, wherein said carrier plate is thermally connected to said heat pipes or rods made of material with high heat conductivity, on which the cooling fins are arranged.

[0019] For example, the cooling fins are plane sheet elements. Alternatively, the cooling fins are curved sheet elements.

[0020] Further, the thickness of the cooling fins may be between 0.1 mm and 2 mm, particularly between 0.3 mm and 0.7 mm, preferably about 0.5 mm.

[0021] Moreover, the distance between two adjacent cooling fins may be between 1 mm and 3 mm, particularly between 1.5 mm and 2.5 mm, preferably about 2 mm.

[0022] The cooling fins may be designed differently from each other, including different shape and/or different material. Said different design may result in different transportation and/or removal of thermal energy.

[0023] A first portion of cooling fins may be arranged at closer distance to the primary cooling body and a second portion may be farther away. Then it may be of advantage to provide the fins of the first portion with a higher thermal mass for them to assume heating power peaks, e.g. in addition to the primary cooling body.

[0024] Preferably, the power component, e. g. the semiconductor switch is fixable within the cooling device, preferably within the secondary cooling body or to the primary cooling body, by at least one clamp or by at least one screw.

[0025] According to an embodiment, the heat-conducting element comprises a first tube section made of a material with higher temperature resistance, preferably copper, and a second tube section made of a material with lower temperature resistance, preferably plastics. The first and second tube sections are connected with each other by means of a plug connection, which may be arranged at and/or penetrating the housing of the household appliance.

[0026] Preferably, at least one cooling fan is assigned to at least one of the primary and secondary cooling bodies for an intensified cooling effect. The relevance for providing one or more cooling fans may particularly depend on the ratio between the quantity of power components and their respective generation of heat on the one hand side and the thermal mass providable by the primary cooling body or the level of heat transfer by the heat-conducting element and/or the secondary cooling body on the other hand side. In case of the second cooling body, the allocated fan may be configured and adjusted to provide cooling air flowing over the cooling fins.

[0027] Specifically, the secondary cooling body is adapted to be arranged at or within the effective area of domestic furnishing or equipment, in particular kitchen furnishing or equipment, for an intensified cooling effect. Said domestic furnishing or equipment may be water supply and/or water discharge system(s) in order to establish water cooling of at least one of the primary cooling body, the secondary cooling body and heat-conducting means. Additionally or alternatively, an exhausting system of an exhaust hood may be used, e.g. by arranging the secondary cooling body within the effective area of a flow channel of an exhaust hood in order to increase removal of heat from the surface of the secondary cooling body.

[0028] Moreover, the present invention relates to an induction generator for an induction cooking hob, wherein said induction generator comprises at least the power component and the primary cooling body as defined above for the usage in the afore-described household appliance.

[0029] Novel and inventive features of the present invention are set forth in the appended claims.

[0030] The present invention will be described in further detail with reference to the drawings, in which

FIG 1 illustrates a schematic perspective view of a cooling device for at least one semiconductor switch according to a first embodiment of the present invention,

FIG 2 illustrates a schematic perspective view of the cooling device for at least one semiconductor switch according to a second embodiment of the present invention, and

FIG 3 to 5 illustrate schematically different kitchen in-

stallation solutions.

[0031] FIG 1 illustrates a schematic perspective view of a cooling device 10 for at least one semiconductor switch according to a first embodiment of the present invention. Particularly, the semiconductor switch is provided for an induction generator of an induction cooking hob 20. Preferably, the semiconductor switch is an insulated-gate bipolar transistor (IGBT).

[0032] The cooling device 10 comprises a solid plate 16, i. e. a thick sheet element, and a plurality of cooling fins 12. Solid plate 16 and the plurality of cooling fins 12 are connected with each other by means of heat transfer rods 14, which provide for a rapid heat transfer between the solid plate 16 and the cooling fins 12.

[0033] In this example, the cooling device 10 comprises about forty cooling fins 12. Said cooling fins 12 have substantially the same size and are arranged parallel to each other, so that the cooling device 10 has a layered structure. Each cooling fin 12 is formed as a thin layer. Preferably, the cooling fins 12 are equally spaced from each other. In this example, the cooling fins 12 have thickness of about 0.5 mm and the distance between two adjacent cooling fins 12 is about 2 mm.

[0034] Preferably, the cooling fins 12 are made of metal, e.g. of steel, stainless steel or aluminium. Cooling channels are formed in the intermediate spaces between the adjacent cooling fins 12. Further cooling channels may be formed by recesses or cuts in the cooling fins 12. In this example, the cooling fins 12 are even sheet elements. Alternatively, the cooling fins 12 may be bent, wherein preferably the distance between adjacent cooling fins 12 is constant.

[0035] According to one example, the semiconductor switch is embedded within the layered structure formed by the cooling fins 12. The semiconductor switch is partially or completely enclosed by said layered structure. A hollow space is formed in the layered structure formed by the cooling fins 12. The semiconductor switch is placed in said hollow space and fixed by a clamp or a screw. Moreover, a pair of semiconductor switches may be placed in the hollow space.

[0036] However, the present example as illustrated with FIG 1 provides for the semiconductor switch being connected to the solid plate 16, which works as a direct recipient of heat energy generated by the semiconductor switches during their operation. Particularly at the moment of starting the operation of the semiconductor switches an increased level of heat energy generation is to be recorded and the solid plate 16 is configured to assume such heating power peak, at least for a short period of time. The solid plate 16, in that, forms a primary cooling body. Thereafter, the heat energy assumed by the solid plate 16 is removed from the solid plate 16, either directly to the ambient air by emitting via its surface, or by way of transmission to the plurality of cooling fins 12, which forms a secondary cooling body in that sense.

[0037] Looking at the latter way, the afore-mentioned set of heat transfer rods 14 provides for the heat energy transport from the solid plate 16 to the plurality of cooling fins 12. The heat transfer rods 14 penetrate the cooling fins 12 and therefore the layered structure of the cooling device 10. In this example, as illustrated, the first ends of six heat transfer rods 14 penetrate the layered structure of the cooling device 10. The heat transfer rods 14 extend perpendicular to the plane of the cooling fins 12. Preferably, the heat transfer rods 14 are made of copper. The second ends of the heat transfer rods 14 are connected to the solid plate 16. In this example, the solid plate 16 extends parallel to the cooling fins 12. For example, the solid plate 16 is made of steel. The heat is transferred from the cooling fins 12 via the heat transfer rods 14 to the solid plate 16.

[0038] FIG 2 illustrates a schematic perspective view of the cooling device 10 for at least one semiconductor switch according to a further embodiment of the present invention. Particularly, the semiconductor switch is provided for an induction generator of an induction cooking hob 20. The dimensions and the structure of the cooling device 10 are selected in a way that a smaller and flatter construction allows an implementation of the complete cooling device 10 inside of the induction cooking hob 20, whereas the example embodiment according to FIG 1, described above, is designed for a split arrangement, as will be described further down below.

[0039] The cooling device 10 according to the embodiment illustrated with FIG 2 comprises the plurality of cooling fins 12 forming the layered structure. In this example, the cooling device 10 comprises about thirty cooling fins 12. All cooling fins 12 have substantially the same size and are arranged parallel to each other. The cooling fins 12 are formed as thin layers. Preferably, the cooling fins 12 are equally spaced from each other. In this example, the cooling fins 12 have a thickness of about 0.5 mm and the distance between two adjacent cooling fins 12 is between 1 mm and 5 mm, in particular about 2 mm. Compared to the cooling fins 12 of FIG 1, the cooling fins 12 of FIG 2 are slimmer and more elongated.

[0040] Preferably, the cooling fins 12 are made of metal, e.g. of steel, stainless steel or aluminium. The cooling channels are formed in the intermediate spaces between the adjacent cooling fins 12. Additional cooling channels may be formed by recesses or cuts in the cooling fins 12.

[0041] In accordance with the first example according to FIG 1, also the example as illustrated with FIG 2 provides for the semiconductor switch being connected to the solid plate 16, which works as a direct recipient of heat energy generated by the semiconductor switches during their operation, i. e. the solid plate 16, in that, forms a primary cooling body. The heat energy assumed by the solid plate 16 is removed from the solid plate 16, either directly to the ambient air by emitting via its surface, or by way of transmission to the plurality of cooling fins 12 forming a secondary cooling body.

[0042] Further, the set of heat transfer rods 14 penetrates the cooling fins 12 and the layered structure of the

cooling device 10. In this example, four heat transfer rods 14 penetrate the layered structure of the cooling device 10. The heat transfer rods 14 extend perpendicular to the plane of the cooling fins 12. Preferably, the heat transfer rods 14 are made of copper. At least a part of the heat transfer rods 14 are formed as one or more serpentines .

[0043] The cooling device 10 of the present invention allows an efficient cooling of one or more semiconductor switches. The thermal mass of the cooling device 10 is efficiently used.

[0044] As can be seen in FIGs 1 and 2, the heat transfer rods 14 are flexibly and individually realizable. Particularly its length and curvature is adaptable to installation conditions. As indicated above, the example embodiment according to FIG 1 is configured for a split assembly, i. e. the solid plate 16 may be arranged inside the induction cooking hob 20, as working as connecting surface for the semiconductor switches, and the layered cooling fins 12 may be arranged outside of the housing of the induction cooking hob 20. Both components, solid plate 16 and layered cooling fins 12, may be connected with the heat transfer rods 14 which penetrated the hob housing.

[0045] FIGs 3 to 5 illustrate schematically different solutions for placements of the layered cooling fins arrangements outside of the induction cooking hob 20 in a typical kitchen furniture. The arrangement according to FIG 3 is a popular and standard furnishing design. The illustration shows a cross-sectional view on the location of installation of an induction cooking hob 20 within a worktop 22 of a kitchen block 24. A built-in oven 26 is arranged within the kitchen block 24 beneath the induction cooking hob 20.

[0046] According to the schematic illustration of FIG 3, the layered cooling fins arrangement 12 is placed outside of the induction cooking hob 20 at different locations for its placement 12a, 12b, 12c, 12d. A first placement 12a being that one closest to the induction cooking hob 20 is an installation within a space between oven 26 and induction cooking hob 20. The heat transfer rod 14, indicated only with its first end coupled to the cooling fins arrangement 12 and cut for reasons of clarity, selected for the connection to the solid plate 16 is a rather short one. A second 12b and third 12c placement of the cooling fins arrangement represent the space between the oven 26 and the inner wall of the kitchen block 24 or the space between the outer wall of the kitchen block 24 and the kitchen wall. For these examples the heat transfer rod 14 to be selected has to be a longer one. Finally, the solution with the comparably longest version for a heat transfer rod 14 is a placement 12d in the plinth area of the kitchen block 24.

[0047] FIG 4 illustrates a more modern kitchen furniture representing a kitchen island. The respective kitchen block 24 of this island is characterized by a back-to-back installation of the furniture with the induction cooking hob 20 being installed in the worktop 22 of the kitchen island block 24. Similar to the solution according to FIG 3, the layered cooling fins arrangement 12 may be placed beneath the worktop 22 close to the induction cooking hob 20, in the situation of FIG 4 between the furniture elements arranged back-to-back, see placement 12e. Further similar to FIG 3, a potential placement of the cooling fins arrangement 12f is in the plinth area of the kitchen island block 24.

[0048] Finally, the example embodiment of FIG 5 is based on a foldable induction cooking hob 20 which can be swivelled from an active, horizontal position, in which it is supported by the worktop 22, to a vertical idle position. According to FIG 5, the foldable induction cooking hob 20 is arranged in a kitchen with popular and standard furnishing design similar to the example according to FIG 3. As illustrated by FIG 5, one potential position 12g of the layered cooling fins arrangement 12 is established between the back wall of the kitchen block 24 and the kitchen wall.

[0049] The heat transfer 14 rods are preferably designed as a heat pipe solution. Such heat pipes are nowadays freely available as standard devices in different lengths and with different curvatures, what causes them to be useable as an assembly kit together with the layered cooling fins structure 12.

[0050] Although an illustrative embodiment of the present invention has been described herein with reference to the accompanying drawings, it is to be understood that the present invention is not limited to that precise embodiment, and that various other changes and modifications may be affected therein by one skilled in the art without departing from the scope or spirit of the invention. All such changes and modifications are intended to be included within the scope of the invention as defined by the appended claims.

List of reference numerals

[0051]

10	cooling device
12	cooling fins / cooling fins arrangement
12a...12g	placements of cooling fins arrangement
14	heat transfer rod
16	solid plate
20	induction cooking hob
22	worktop
24	kitchen block
26	oven
28	drawer

Claims

1. A household appliance (20), particularly a cooking hob, more particularly an induction cooking hob, with a circuit board comprising a power component, in particular a semiconductor switch, the power component being in heat-conducting connection with a

cooling device (10), the cooling device (10) comprising a primary cooling body (16) and a secondary cooling body (12), the primary and secondary cooling bodies (12, 16) are in heat-conducting connection with each other by means of at least one heat-conducting element (14) to that effect that the primary cooling body (16) is adapted to receive thermal energy from the power component which is heated up during its operation and to transmit the received thermal energy at least partially to the secondary cooling body (12).

2. The household appliance according to claim 1, wherein at least the secondary cooling body (12) is or comprises a large-area surface or a large-scale wall or plate of the household appliance (20) or of a surface or wall adjacent to the household appliance (20).

3. The household appliance according to claim 1 or 2, wherein the primary and/or the secondary cooling body (12) comprise(s) a plurality of cooling fins (12) forming a layered structure, the cooling fins (12) preferably being arranged parallel to each other.

4. The household appliance according to claim 3, wherein the layered structure formed by the cooling fins (12) includes at least one hollow space, which is provided for receiving at least one power component, so that the power component is partially or completely enclosed by the cooling fins (12) .

5. The household appliance according to claim 3 or 4, wherein the cooling device (10), particularly the heat conducting element (14), comprises at least one heat transfer rod or tube penetrating at least a part of the cooling fins (12), wherein the heat transfer rod or tube preferably extends perpendicular to said cooling fins (12).

6. The household appliance according to anyone of the preceding claims, wherein the heat-conducting element (14) is or comprises a heat pipe.

7. The household appliance according to anyone of the preceding claims, wherein the secondary cooling body (12) is configured to be arranged outside of the household appliance (20), wherein preferably the heat-conducting element (14) is adaptable or adjustable to the installation conditions for the household appliance (20) and/or the heat-conducting element (14) is movable, particularly slidable, as against the primary (16) and/or the secondary (12) cooling body.

8. The household appliance according to anyone of the preceding claims, wherein the primary cooling body (16) provides a thermal mass and/or is configured to serve as heat buffer for heat power peaks, particularly appearing as overshoots during an activation of the power component.

9. The household appliance according to anyone of the preceding claims, comprising a plurality of secondary cooling bodies of smaller dimension, wherein the secondary cooling bodies are connected by the heat-conducting element (14) amongst themselves and the plurality of secondary cooling bodies is connected to the primary cooling body by means of the heat-conducting element (14), or wherein each one of the plurality of secondary cooling bodies is individually connected to the primary cooling body (16) by means of the heat-conducting element (14).

10. The household appliance according to anyone of the claims 3 to 5, wherein the cooling fins (12)

- include a plurality of holes with engraved edges and/or
- are equally spaced from each other and/or
- are made of material having high heat conductivity and/or
- are plane sheet elements and/or curved sheet elements and/or
- have a thickness of between 0.1 mm and 2 mm, particularly between 0.3 mm and 0.7 mm, preferably about 0.5 mm, and/or
- are disposed from an adjacent cooling fin (12) at a distance of between 1 mm and 3 mm, particularly between 1.5 mm and 2.5 mm, preferably about 2 mm.

11. The household appliance according to anyone of the preceding claims, wherein the power component is fixable within the secondary cooling body (12) or to the primary cooling body (16) by at least one clamp or by at least one screw.

12. The household appliance according to anyone of the preceding claims, wherein the heat-conducting element (14) comprises a first tube section made of a material with higher temperature resistance, preferably copper, and a second tube section made of a material with lower temperature resistance, preferably plastics, the first and second tube sections being connected with each other by means of a plug connection, the plug connection particularly being arranged at and/or penetrating the housing of the household appliance (20).

13. The household appliance according to anyone of the preceding claims, wherein at least one cooling fan is assigned to at least one of the primary (16) and secondary (12) cooling bodies for an intensified cooling effect.

14. The household appliance according to anyone of the

preceding claims, wherein the secondary cooling body (12) is adapted to be arranged at or within the effective area of domestic furnishing or equipment, in particular kitchen furnishing or equipment, for an intensified cooling effect, particularly using water cooling means or an exhausting system of an exhaust hood.

15. An induction generator for an induction cooking hob, comprising at least the power component and the primary cooling body (16) as defined in any one of the claims 1 to 14.

Fig.1

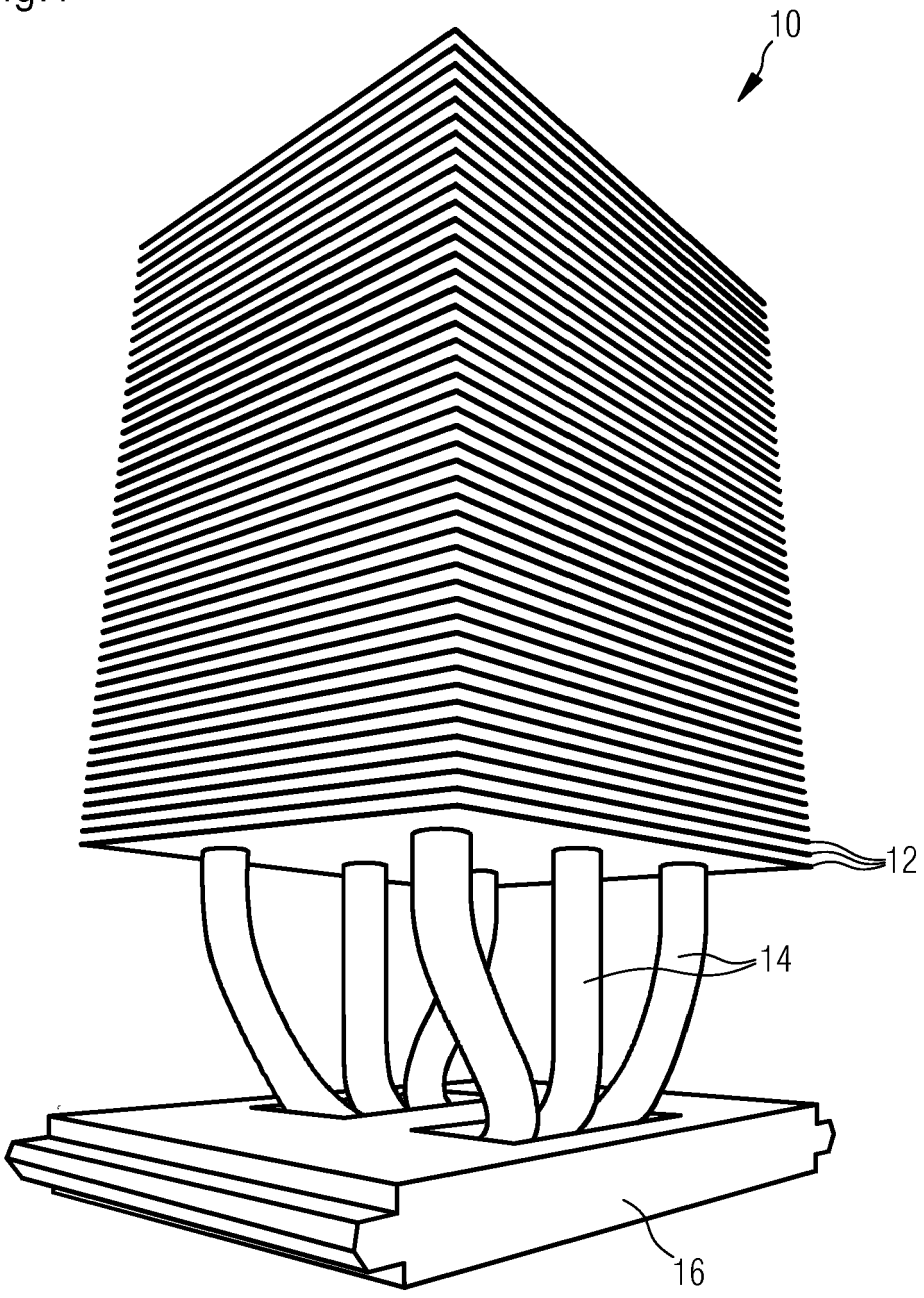


Fig.2

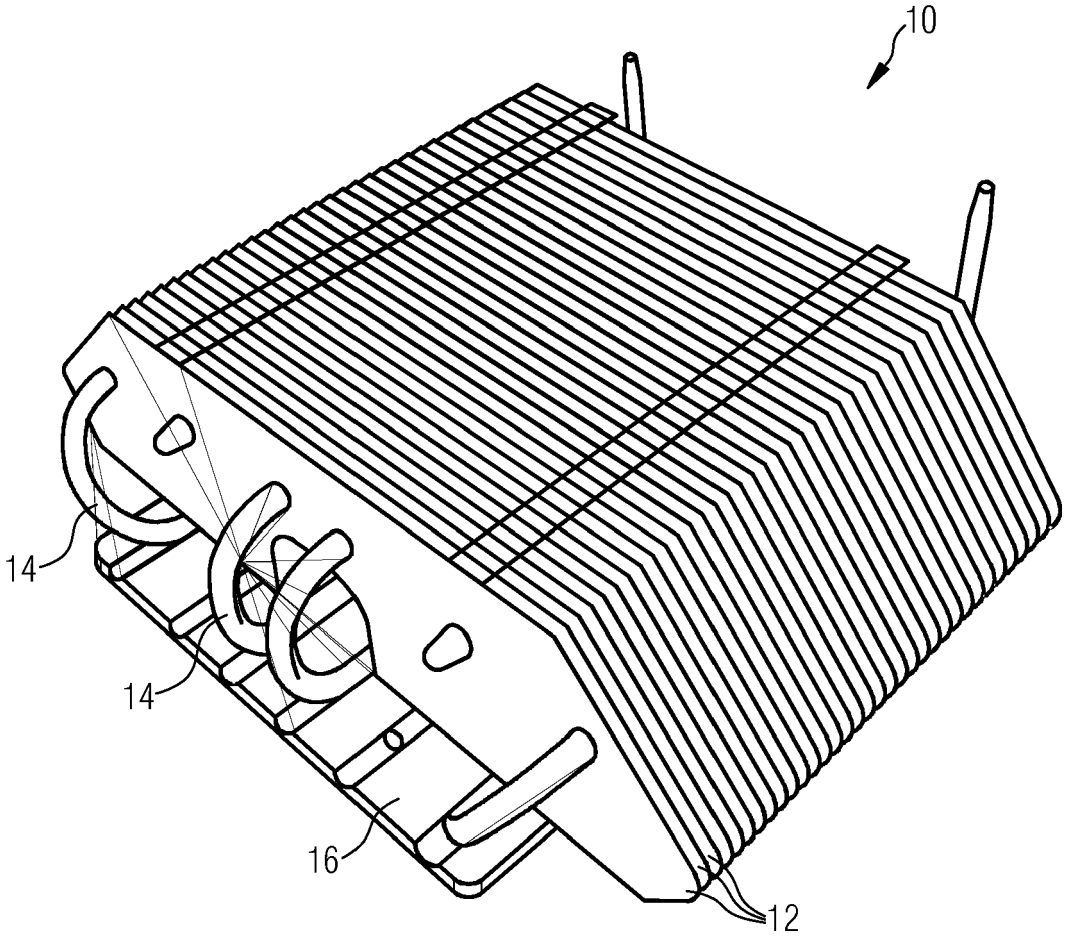


Fig.3

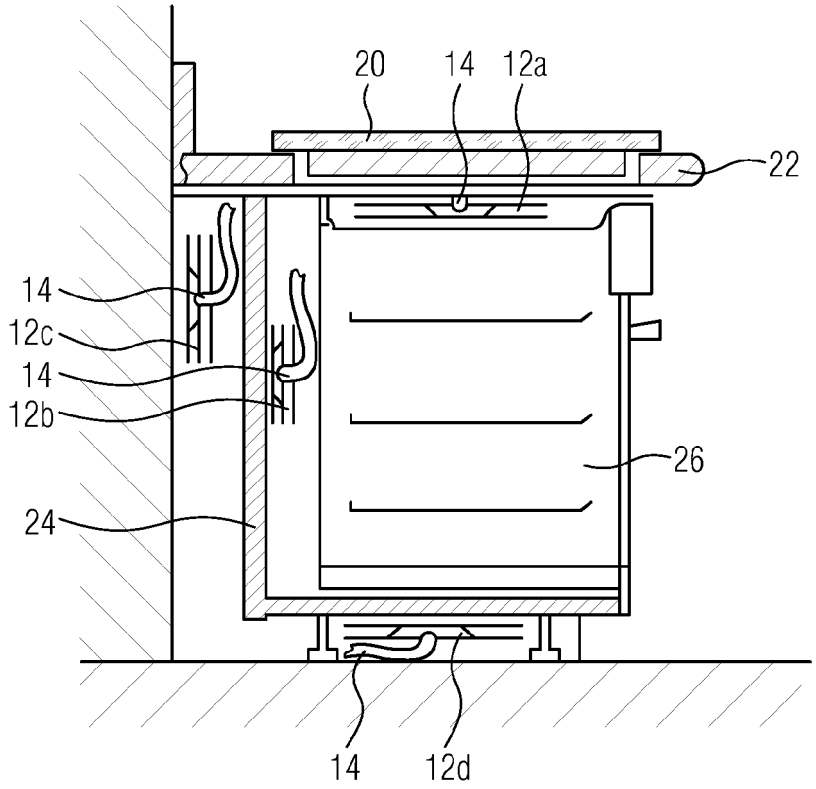


Fig.4

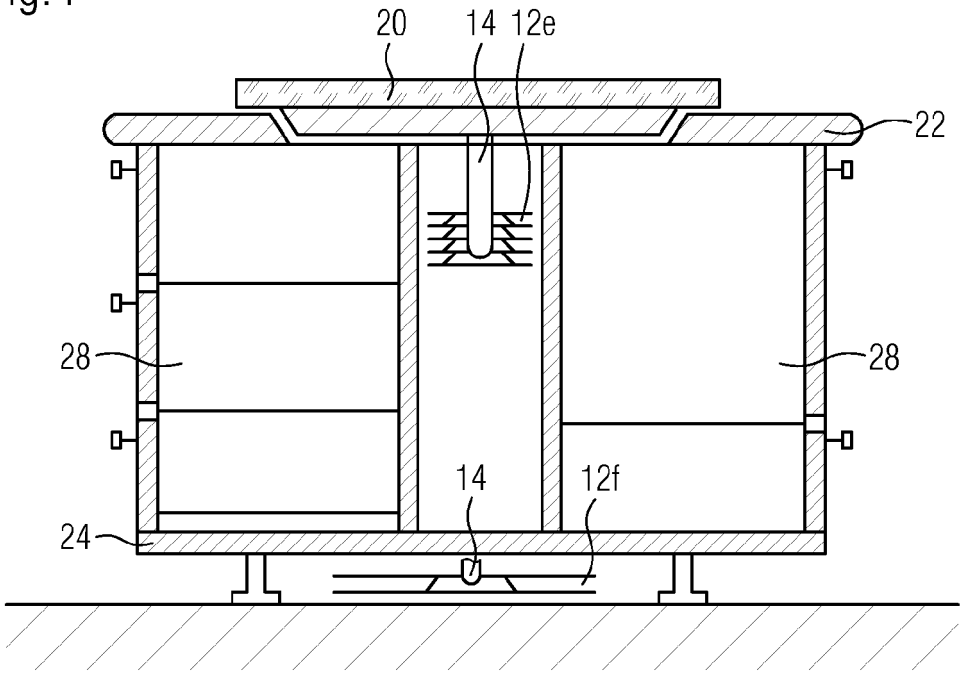
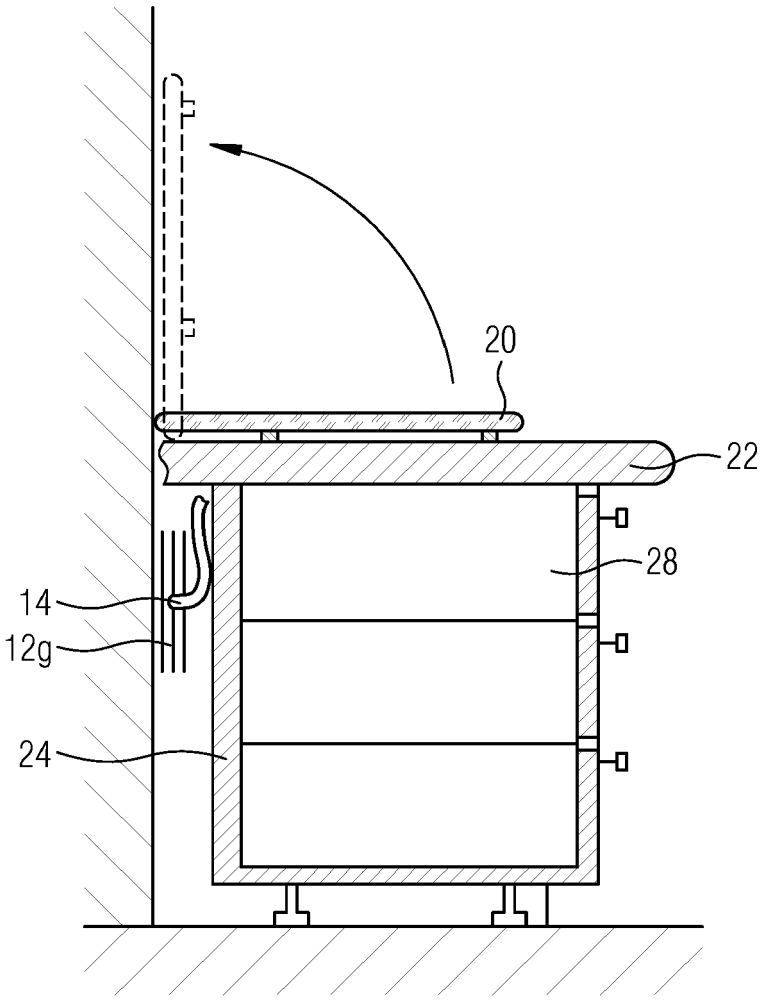


Fig.5



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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 5903

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Y	EP 3 288 073 A1 (SONY INTERACTIVE ENTERTAINMENT INC [JP]) 28 February 2018 (2018-02-28) * paragraphs [0030] - [0037]; figures 3-5 *	4	
Y	US 6 466 441 B1 (SUZUKI MASAHIRO [JP]) 15 October 2002 (2002-10-15) * column 6, lines 33-53; figures 5,20 *	4	
E	EP 3 544 379 A1 (LG ELECTRONICS INC [KR]) 25 September 2019 (2019-09-25) * paragraphs [0032] - [0050], [0067] - [0072]; figures 2-7 *	1	TECHNICAL FIELDS SEARCHED (IPC) H05B F24C H05K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 December 2019	Aubry, Sandrine

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 18 5903

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82