Description of the Application

[001] The present application relates to cooking using solar radiation ("solar cooking"). Solar cooking is environmentally friendly and suitable for remote areas without a reliable supply of fuel or electricity.

[002] The document D1 discloses a conventional cooking process wherein solar radiation is concentrated by a parabolic mirror onto a light-absorbing plate (see Fig. 1 of D1). Said plate heats up upon absorption of solar radiation, cooking the food placed on top of it. Said process does not however function on cloudy days or during the night. The plate quickly cools down in the absence of solar radiation, interrupting the cooking process. Therefore, there is a need to store heat for the cooking process.

[003] Heat is normally stored by raising the temperature of a material. To increase the amount of heat stored, the material thus has to reach high temperatures, with the disadvantage that the system has to sustain a wide temperature range.

[004] An alternative way of storing heat is based on the change of phase of a material. This involves heating the material until it reaches its melting temperature. Additional heat supplied to the material during melting does not increase its temperature but instead induces the change of phase from solid to liquid. The amount of heat necessary to complete the phase change is called “heat of fusion” and is released back by the material upon solidification.

[005] Heat storage based on change of phase is advantageous for solar cooking because, during melting, the temperature of the material is kept constant at the melting temperature, thereby avoiding exposure of the solar cooker and especially the food to large temperature variations. The invention concerns solar cooking with heat storage based on this principle.

[006] The invention uses salt compositions, which provide an appropriate melting temperature and good thermal conductivity, as the material subject to the change of phase. Salt compositions particularly suitable for cooking in accordance with the invention have a melting temperature from 110°C, sufficiently above the boiling temperature of water, to 350°C. Examples of suitable salt compositions are listed in Table 1:

Table 1

	Chemical formula	*Name*	*Melting temp. (°C)*
A	$MgCl_2 \cdot 6H_2O$	Magnesium chloride hexahydrate	115
B	$LiNO_3$ (33%) - KNO_3 (67%)	Lithium nitrate (33%) - Potassium nitrate (67%)	130
C	$AlCl_3$	Aluminium chloride	192
D	$LiNO_3$	Lithium nitrate	252
E	$NaNO_3$	Sodium nitrate	307
F	KNO_3	Potassium nitrate	334
G	LiCl (58%) - KCl (42%)	Lithium chloride (58%) - Potassium chloride (42%)	348

[007] Referring to standard chemical databases, other suitable salt compositions can be found that have melting temperatures identical or close to those indicated in Table 1.

[008] Brief description of the drawings:

Fig. 1 is a schematic drawing of a solar cooker with a heat storage unit as employed in the cooking process of the present invention.

Figs. 2 and 3 show embodiments of the heat storage unit of the present invention.

[009] In Fig. 1, the solar cooker 1 comprises a heat storage unit 3 containing a salt composition 6. In the cooking process of the invention, the solar radiation 12 concentrated by a parabolic mirror 11 heats the heat storage unit 3, thereby melting the salt composition 6 and cooking the food 8. Should the solar radiation 12 be interrupted by clouds or sunset, the salt composition 6 solidifies, releasing its heat of fusion to the food 8. The food 8 thus continues to cook in the absence of solar radiation.

[010] An example of the heat storage unit 3 is shown in Fig. 2. It includes a box 4, provided with heat-insulating walls to avoid heat loss. The box 4 contains a salt composition 6, which can be chosen from Table 1. The box 4 also comprises an empty space 7 dimensioned to allow the salt composition 6 to expand upon melting. A light-absorbing plate 5, e.g. of black anodised aluminium, is fitted in a first opening of the box 4 and is in thermal contact with the salt composition 6. A cooking plate 2 is fitted in a second opening of the box 4 and is also in thermal contact with the salt composition 6, for example using fins 13 extending through the empty space 7. The cooking plate 2 is made of metal or ceramic and provides a cooking surface 9 on which food 8 to be cooked is placed.

[011] In the cooking process, the solar radiation 12 is concentrated on the light-absorbing plate 5. The heat generated by the light-absorbing plate 5 is conducted to the salt composition 6 and to the cooking plate 2. The temperature of the salt composition 6 rises to the melting temperature, at which point the salt composition melts, storing the heat of fusion. At the same time, the food 8 on the cooking surface 9 cooks. When the solar radiation 12 is interrupted, no more heat is generated by the light-absorbing plate 5. However, the salt composition 6 does not cool down rapidly but instead solidifies, releasing the heat of fusion to the cooking plate 2 so that the cooking process continues.

[012] The heat storage unit 3 of Fig. 2 may be detachable from the solar cooker 1 of Fig. 1 and portable. Therefore, the solar cooker 1 can also be used in two steps: in the first step the heat storage unit 3 is mounted in the solar cooker under solar radiation 12 to store heat; in the second step the heat storage unit 3 is detached from the solar cooker and transported elsewhere, e.g. indoors, where food 8 is placed on the cooking plate 2 for cooking. One or more handles 10 may facilitate the transport of the heat storage unit 3.

[013] Fig. 3 shows another example of the heat storage unit 3, especially suitable for the aforementioned two-step operation. As in the example of Fig. 2, a box 4 with heat-insulating walls contains a salt composition 6, which can be chosen from Table 1. The empty space 7 is dimensioned to allow the salt composition 6 to expand upon melting. In this embodiment, the box 4 has only one opening, in which a light-absorbing plate 5 is fitted. In the cooking process, the heat storage unit 3 is first mounted (Fig. 3 (a)) in the solar cooker 1 of Fig. 1 so that solar radiation 12 is concentrated on the light-absorbing plate 5. The temperature of the salt composition 6 rises to the melting temperature, at which point the salt composition 6 melts, storing the heat of fusion. When a sufficient amount of heat is stored, the heat storage unit 3 is detached from the solar cooker 1 and turned upside-down (Fig. 3 (b)) by means of one or more handles 10. Thermal contact between the light-absorbing plate 5 and the melted salt composition 6 is maintained, e.g. by means of fins 13. Food 8 is placed on the surface of the light-absorbing plate 5, which acts as the cooking surface 9 due to the heat of fusion being released from the salt composition 6.

Claims

1. A cooking process including the steps:
providing a heat storage unit (3);
concentrating solar radiation (12) onto the heat storage unit (3) to heat it; and
cooking food (8) placed on the heat storage unit (3).

2. A heat storage unit (3) for use in the process of claim 1, characterised by:
a box (4) having heat-insulating walls and an opening,
the box (4) containing a salt composition (6),
a light-absorbing plate (5) fitted in the opening and in thermal contact with the salt composition (6), and
a cooking surface (9) in thermal contact with the salt composition (6).

3. Heat storage unit according to claim 2, wherein the cooking surface (9) is a surface of a cooking plate (2) fitted in a second opening of the box (4) and in thermal contact with the salt composition (6).

4. Heat storage unit according to claim 2 or 3, wherein the heat storage unit (3) is portable by means of handles (10).

5. Heat storage unit according to claim 2, wherein the cooking surface (9) is a surface of the light-absorbing plate (5).

6. A solar cooker (1) comprising:
a heat storage unit (3) according to any of claims 2 to 5;
a parabolic mirror (11) for concentrating solar radiation (12) on the light-absorbing plate (5) of the heat storage unit (3).

Drawings of the Application

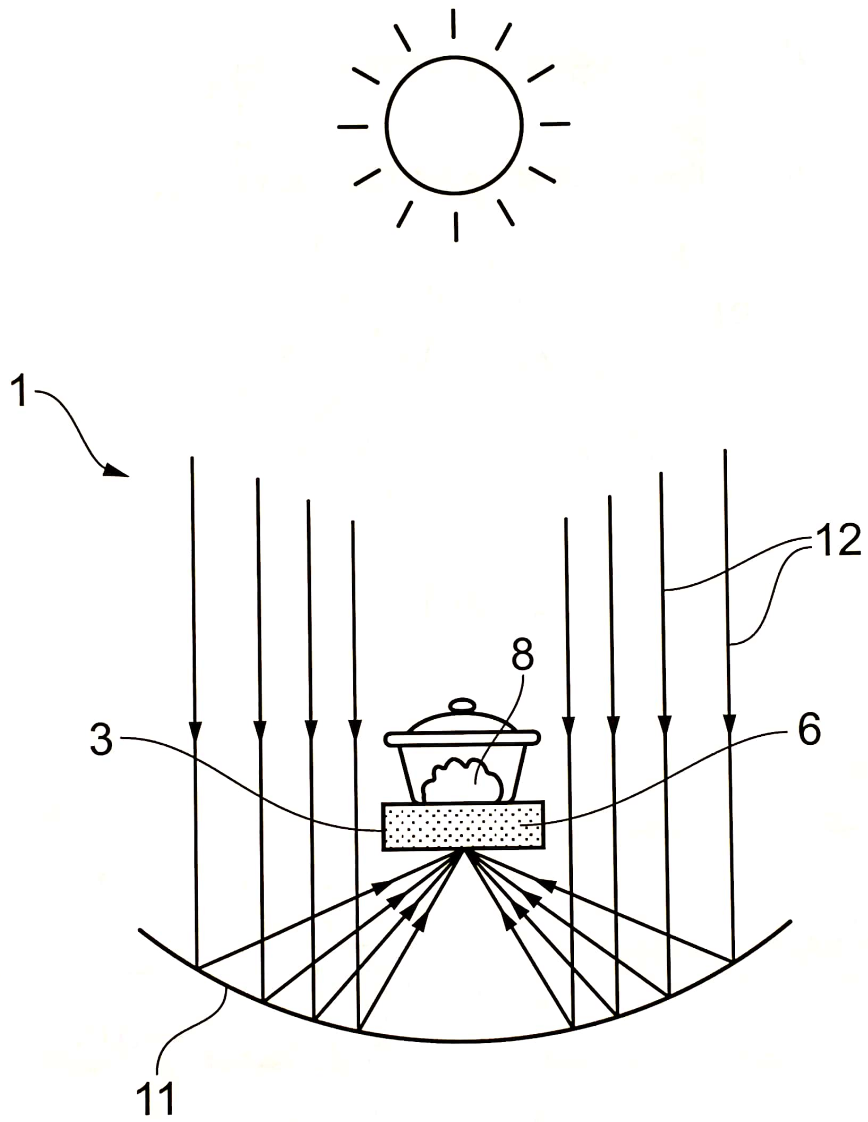


FIG. 1

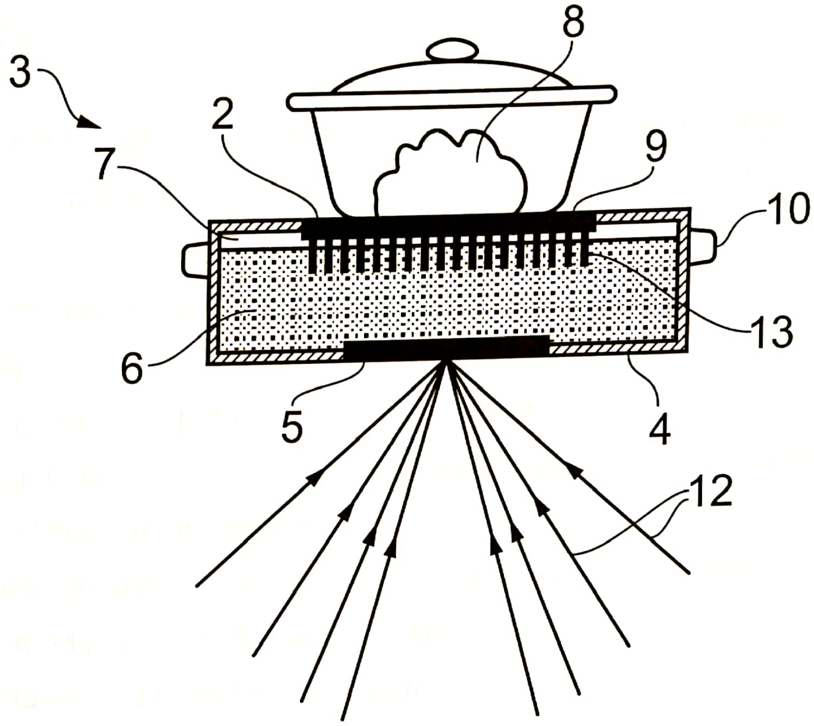


FIG. 2

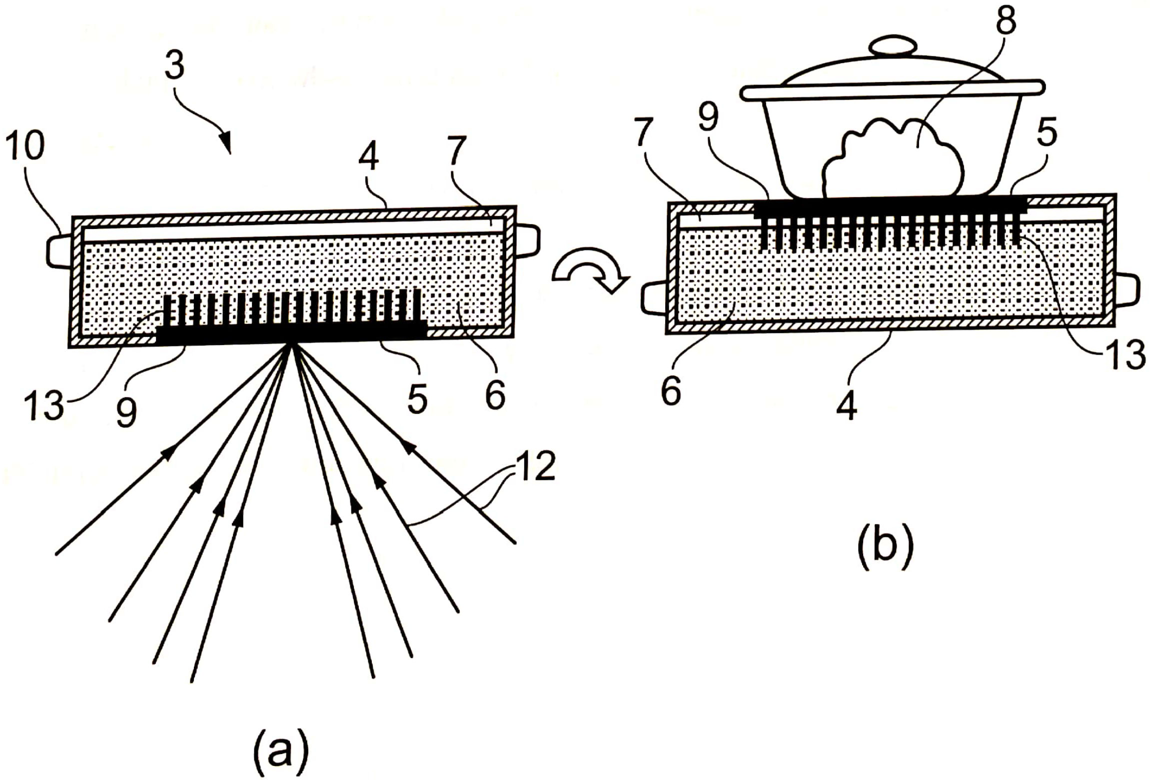


FIG. 3

Communication

1. The examination is based on the application documents as originally filed. Attached documents D1, D2 and D3 are prior art according to Art. 54(2) EPC.

2. The subject-matter of claim 1 is not new in the sense of Art. 54(1) and (2) EPC:
   D1 discloses:
      A cooking process ([003]), including the steps:
      providing a heat storage unit (the heated aluminium plate 2 stores a certain amount of heat when heated);
      concentrating solar radiation onto the heat storage unit to heat it; and
      cooking food placed on the heat storage unit ([003]).
   D1 thus discloses all the features of claim 1.

3. The subject-matter of claim 2 is not new in the sense of Art. 54(1) and (2) EPC:

3.1 D2 discloses:
   A heat storage unit ([001]: the pot contains sodium chloride which *"stores a high quantity of heat when it is brought to high temperatures"*) for use in the process of claim 1 (e.g. when used as in D1, Fig. 2), characterised by (see [001] and the figure of D2):
   a box (A) having heat-insulating walls and an opening, the box containing a salt composition (sodium chloride),
   a light-absorbing plate ("*disk (C) of black anodised aluminium*") fitted in the opening and in thermal contact with the salt composition,
   a cooking surface (B) in thermal contact with the salt composition.
   D2 thus discloses all the features of claim 2.

3.2 D3 discloses:

A heat storage unit for use in the process of claim 1 (the radiator of D3 as in Fig. 1 is suitable to be used as in Fig. 3 of the application), characterised by:
a box (1) having heat-insulating walls and an opening,
the box containing a salt composition (2, see [004]: $MgCl_2 \cdot 6H_2O$),
a light-absorbing plate (3) fitted in the opening and in thermal contact with the salt composition,
a cooking surface (the surface of the plate 3) in thermal contact with the salt composition.

D3, therefore, also discloses all the features of claim 2.

4. Claim 2 lacks an essential feature in the sense of Rule 43(3) EPC and therefore does not satisfy the requirements of Art. 84 EPC. The empty space (7) dimensioned to allow the salt composition to expand upon melting is a feature necessary for the heat storage unit as defined by claim 2 to work.

5. Concerning the claims dependent on claim 2:

5.1 D2 discloses a cooking plate (B) arranged as in claim 3. The pot disclosed by D2 is portable as in claim 4. The subject-matter of these claims is therefore not new.

5.2 D3 discloses a cooking surface as in claim 5. The subject-matter of this claim is therefore not new.

5.3 The subject-matter of claim 6 does not involve an inventive step in the sense of Art. 56 EPC. It would be obvious for the skilled person to use, in the solar cooker of D1 (Fig. 2), a heat-storing pot as in D2 to obtain the advantages mentioned by D2.

6. The applicant is invited to provide an amended set of claims meeting the requirements of the EPC.

D1: Solar cooker with parabolic light concentrator

[001] We present a cooker based on solar radiation. It is environmentally friendly and especially useful in remote areas where electricity or fuel is scarce.

[002] Our cooker (Fig. 1) includes a parabolic mirror 1 and a plate 2 located in the focus of the mirror. The aluminium plate 2 is black anodised on its bottom surface 3, in order to absorb light. The top surface of the plate holds the food 4 to be cooked. The food can be placed either directly on the plate for grilling, or in a pot.

[003] In the cooking process, the parabolic mirror is illuminated by solar light and concentrates it at its focal point on the bottom surface of the plate, which absorbs light and heats up, cooking the food 4. Under concentrated solar light, the plate rapidly reaches suitable cooking temperatures in the order of 120°C and higher. A solid, single-piece plate without internal gaps provides good heat conduction and distribution.

[004] In the version shown in Fig. 2, the plate 2 was substituted with a stand 5 for mounting a pot 4´. The stand 5 has a hole in the centre so that the bottom surface of the pot is at the focal point of the parabolic mirror. In this cooker, the pot is heated directly by the concentrated solar light. Any pot can be used, provided that the bottom surface is light-absorbing, as is the case with a black or matt surface.

D1 - Drawings

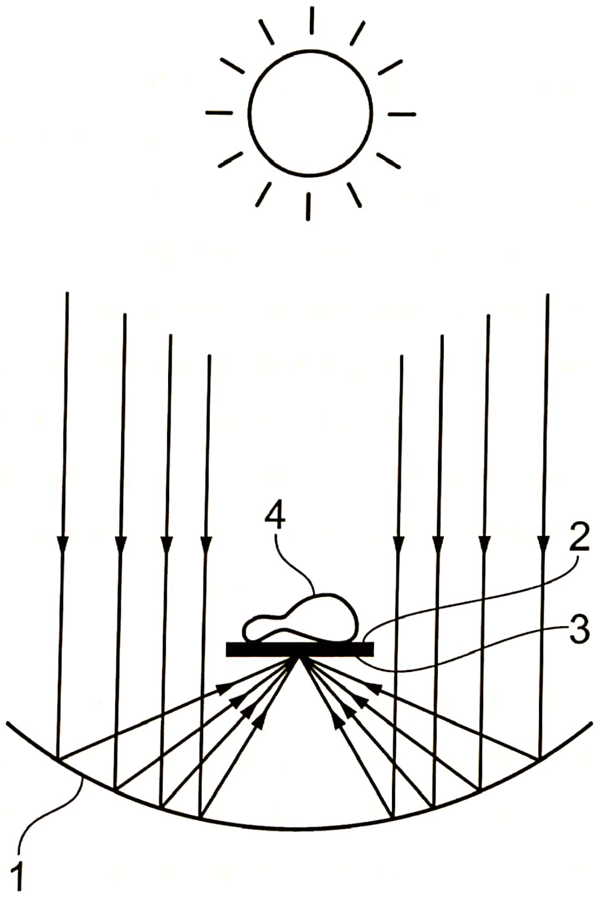


FIG. 1

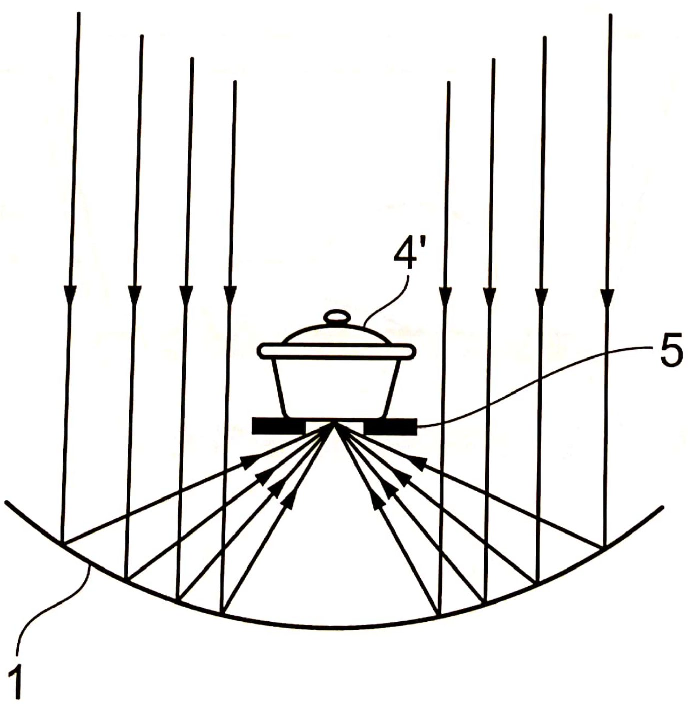
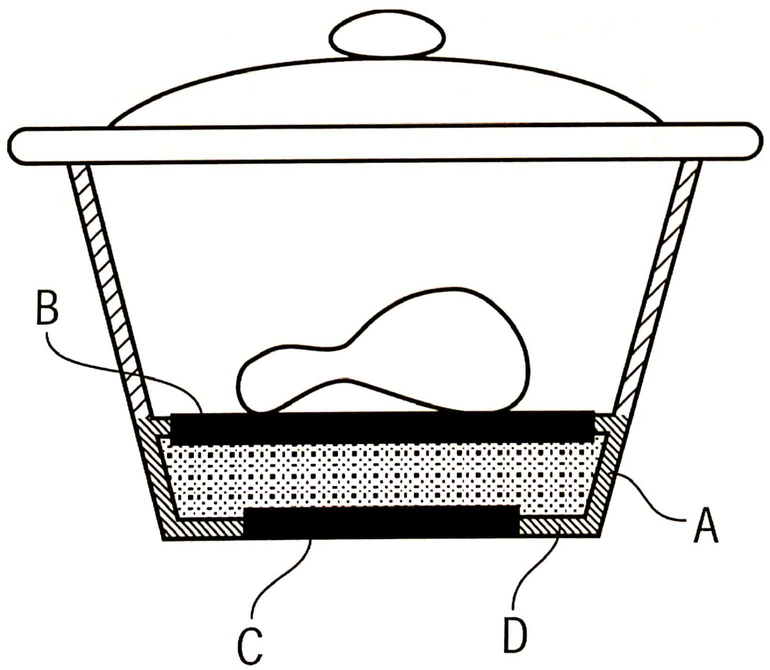


FIG. 2

D2: Cooking pot with salt box

[001] It is common to cook food, especially meat and fish, on a salt bed. Kitchen salt (sodium chloride) provides excellent thermal conductivity and stores a high quantity of heat when it is brought to high temperatures, so the food is cooked evenly and gently. Unfortunately, large amounts of salt have to be thrown away after cooking is completed. We produce cooking pots or pans having a permanent reserve of salt in a sealed container (A), as illustrated in the figure. The top of the container (A) contains a plate providing the cooking surface (B). The bottom of the container (A) is sealed by a disk (C) of black-anodised aluminium , for collecting heat from a cooker (e.g. a gas flame). The salt ensures good thermal flow from the disk (C) to the cooking surface (B). The rest (D) of the container (A) is thermally insulated.

[002] The salt is in granular form. The gaps between the grains allow air circulation inside the container, thereby distributing heat more uniformly. Advantageously, sodium chloride is non-toxic, very stable and maintains this granular state up to its melting temperature of around 800°C, far higher than normal cooking temperatures.



D3: "Portable radiator with storage of solar heat", Journal of Camping Science, Summer 2016

[001] We have developed a portable heat radiator which stores solar heat during the daytime and releases it in the evening. It does not rely on gas or electricity, it is safe and it is especially useful for holiday homes or camping. The heat storage is based on the properties of a phase-change material (PCM), which stores and releases the heat of fusion upon melting and solidification respectively. The portable radiator 9 (see Fig. 1) consists of a heat-insulating box 1 containing a PCM 2 and a space to allow the thermal expansion of the PCM. A light-absorbing plate 3 of black ceramic is fitted to a side of the box, in thermal contact with the PCM 2. The box 1 also has two hinged covers 4 of insulating material, which can be closed against the plate 3 or opened to expose the plate to sunlight 8, as in Fig. 1. On the side opposite the plate 3, the PCM 2 is in thermal contact with a metal block 5 (shown in the cut-away view of Fig. 1 under the insulating layer 11), including air conduits 6. These conduits are open to the outside at both ends through openings 10 in the insulating layer 11.

[002] To store heat, the hinged covers 4 are opened, exposing the light-absorbing plate 3 to sunlight (see Fig. 1). The plate 3 heats up and melts the PCM 2. The covers 4 are then closed and the radiator 9 is transported to the space to be heated, where it is put in an upright position (see Fig. 2). Upon solidification, the heat of fusion is released by the PCM 2 to the air in the conduits 6. Heated air 7 flows by convection through the openings 10 to the surrounding environment.

[003] Organic materials such as fatty acids having a melting temperature between 40 and 80°C provide suitable PCMs for this radiator. These temperatures correspond to the conventional internal temperatures of domestic heaters and are rapidly reached by the light-absorbing plate 3 when exposed to sunlight 8. The quantity of PCM determines the amount of heat stored and is thus calculated depending on the space to be heated. A radiator having external dimensions of 30 x 40 x 15 cm, containing 1200 cm^3 of stearic acid (a non-toxic fatty acid having a melting temperature of 70°C), was found sufficient to heat a two-person tent to a comfortable temperature for several hours.

[004] The hydrated salt $MgCl_2 \cdot 6H_2O$, normally used to prevent ice on roads, was also tested as a PCM. This composition has however the disadvantage of a high melting temperature of 115°C. Reaching this temperature under average sunlight and melting the material takes a long time. Furthermore, such a high temperature is not only unnecessary for our radiator but also dangerous, since burns or fires could result from accidental opening of the covers 4 and contact with the plate 3.

D3 - Drawings

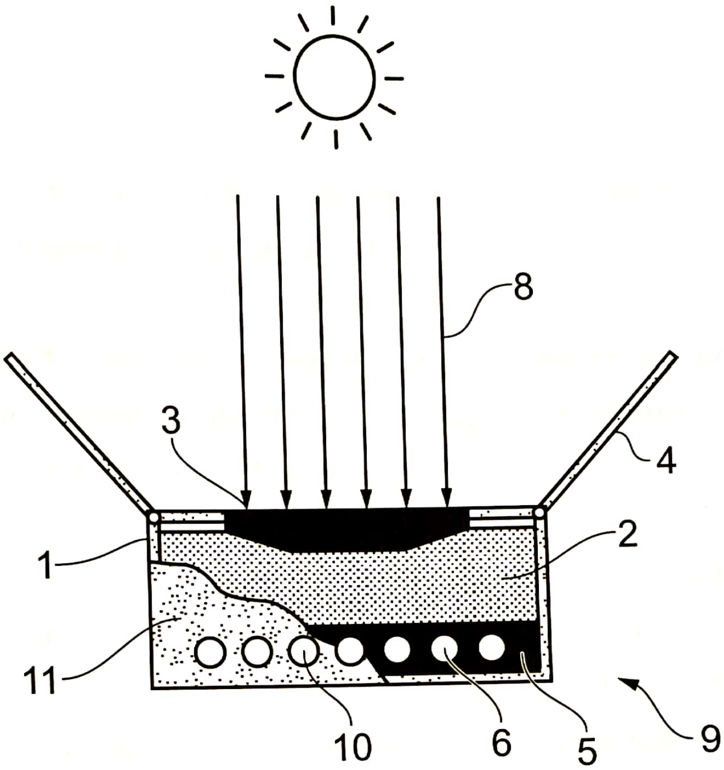


FIG. 1

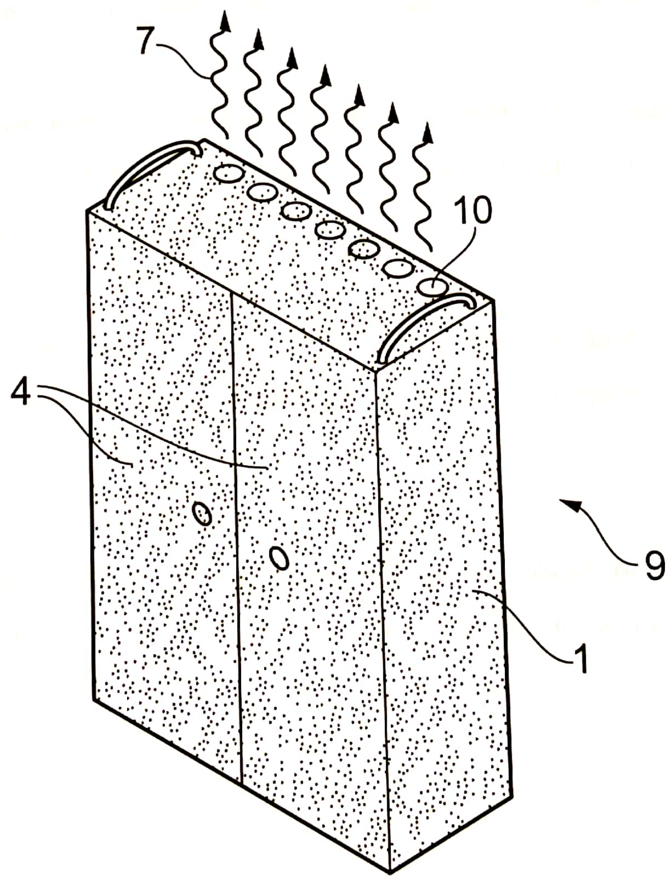


FIG. 2

Client's letter

Dear Mr. Marcellus,

Please see the attached set of claims, which in our opinion meets the requirements of the EPC and also satisfies our business needs.

The process of claim 1 now involves a salt composition. We do not consider it necessary to specify the range of melting temperatures, as long as the process includes melting the salt composition to store the heat of fusion.

However, a limitation of the melting temperatures seems to be necessary to overcome the objections against claim 2. Furthermore, after further tests we have abandoned the use of the salt composition A ($MgCl_2 \cdot 6H_2O$). The material with the lowest melting temperature that we plan to use in commercial products is the salt composition B. The range of melting temperatures from 120°C to 350°C of claim 2 should exclude salt composition A but include salt composition B (melting temperature of 130°C) and the remaining salt compositions. Sodium chloride as in D2 does not melt at cooking temperatures and thus does not store as much heat as our invention.

We agree to include the empty space in the heat-storage unit of claim 2. All our products comprise this feature: it is indeed the only practical way to allow the expansion of the salt composition upon melting.

Furthermore, we have rearranged claims 4 and 5 in order to claim a portable heat storage unit with one or more handles for the second embodiment of our invention as well as for the first one.

Please make any amendments to these claims that you consider necessary to meet the requirements of the EPC, without adding further dependent claims.

Kind regards,
Dr. Archimedes

Amended claims

1. A cooking process including the steps:
providing a heat storage unit (3) <u>containing a salt composition (6)</u>;
concentrating solar radiation (12) onto the heat storage unit (3) to heat it; and
cooking food (8) placed on the heat storage unit (3).

2. A heat storage unit (3) for use in the process of claim 1, ~~characterised by~~ <u>comprising</u>:
a box (4) having heat-insulating walls and an opening,
the box (4) containing a salt composition (6) <u>and comprising an empty space (7)</u>,
a light-absorbing plate (5) fitted in the opening and in thermal contact with the salt composition (6), and
a cooking surface (9) in thermal contact with the salt composition (6),
<u>characterised in that:</u>
<u>the salt composition (6) has a melting temperature from 120°C to 350°C.</u>

3. Heat storage unit according to claim 2, wherein the cooking surface (9) is a surface of a cooking plate (2) fitted in a second opening of the box (4) and in thermal contact with the salt composition (6).

<u>4.</u> ~~5.~~ Heat storage unit according to claim 2, wherein the cooking surface (9) is a surface of the light-absorbing plate (5).

<u>5.</u> ~~4.~~ Heat storage unit according to <u>any of</u> claim<u>s</u> 2 ~~or 3~~ <u>to 4</u>, wherein the heat storage unit (3) is portable by means of handles (10).

6. A solar cooker (1) comprising:
a heat storage unit (3) according to any of claims 2 to 5;
a parabolic mirror (11) for concentrating solar radiation (12) on the light-absorbing plate (5) of the heat storage unit (3).