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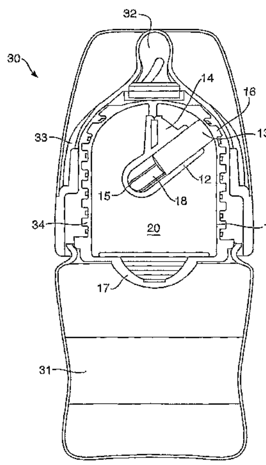
**(54) Title**: PHASE CHANGE INITIATOR FOR USE WITH AN EXOTHERMIC PHASE CHANGE MATERIAL

Fig.2.




**(57) Abstract**: The phase change initiator (11) is provided within a heat pack (10) consisting of substantially rigid walls and containing an exothermic phase change material (20). The initiator (11) includes a piston arrangement (12) which has slots (15) in its casing to provide fluid communication between the interior of the piston arrangement (12) and the phase change material (20) in the heat pack. Operation of the plunger (13) of the piston arrangement (12) acts to compress phase change material within the piston arrangement (12) to trigger initiation of a phase change which is then communicated to phase change material outside of the piston arrangement. The initiator (11) enables the use and activation of exothermic phase change material within a rigid casing.

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# PHASE CHANGE INITIATOR FOR USE WITH AN EXOTHERMIC PHASE CHANGE MATERIAL

## Field of the Invention

**[0001]** The present invention relates to a mechanism to initiate the change of phase of an exothermic phase change material. Also, the present invention is concerned with a heat generating unit or heat pack employing the phase change initiator. Particularly, but not exclusively, the present invention is suited for use with a heat-pack used to heat fluids such as, for example, milk in a baby's feeding bottle.

## Background of the Invention

**[0002]** The use of initiators to activate a phase change in an exothermic phase change material is known. For example, gel pack pocket hand warmers in the form of flexible bags containing an initiator in the form of a small metal disk. To initiate a phase change, the user presses into the gel pack to snap the small metal disk located within the gel pack, deforming the small metal disk and generating a nucleation centre which activates a phase change in the phase change material. This phase change then spreads to the rest of the phase change material in the gel pack. When the pressure applied by the user is released, the small metal disk returns to its original shape.

**[0003]** However there are a number of problems with these types of initiators. Firstly, the phase change initiator has to be positioned such that a user can apply a force to it directly. As the initiator is generally positioned within a pack containing a larger source of the phase change material, the pack must be made of a flexible material. This limits the applications for which the phase change initiator can be used. In general the use of phase change materials as a source of heat has been limited to flexible gel packs used as pocket/hand warmers and muscle relaxants.

**[0004]** Secondly, the known types of initiators do not reliably or consistently initiate a phase change. A user may have to squeeze or snap the initiator several times before a phase change reaction commences. On the other hand, these initiators are also susceptible to inadvertent triggering for example when a gel pack is dropped or jarred.

Summary of the invention

**[0005]** The present invention seeks to address the problems encountered with known phase change initiators. In particular, an object of the present invention is to provide a phase change initiator which is not restricted to flexible packs.

**[0006]** A phase change initiator for use with an exothermic phase change material in accordance with the present invention comprises a housing having an initiation chamber therein containing a plurality of grains, the housing having one or more openings dimensioned to retain said grains in said initiation chamber and to allow fluid communion between the interior and the exterior of the initiation chamber, said phase change initiator being characterised by the housing being substantially rigid and by the phase change initiator further comprising a plunger, a first end of the plunger being slidably received in the initiation chamber and a second end of the plunger, remote from the first end of the plunger, being adapted for manual operation.

**[0007]** The one or more grains are resistant to deformation under manually applied forces. Ideally, the grains have a Young's modulus of between 40 GPa and 100 GPa, more preferably over 60 GPa. More preferably still, the one or more granular materials are of soda glass. Also, the surface of the grains is either curved or irregular so as to present only a small (relative the total surface area of the grain) contact region when two grains contact with one another and the surface includes surface inclusions that are smaller that the surface contact region.

**[0008]** Ideally each of the plurality of grains is spherical and may have a diameter of between 1 mm and 10 mm, more preferably 2.5 mm.

**[0009]** In a preferred embodiment the plunger is biased towards a first position of maximum volume in the initiation chamber.

**[0010]** In a separate aspect the present invention provides a heat pack comprising a phase change initiator as described above and an exothermic phase change material, the phase change initiator being operable for activating a phase change of the exothermic phase change material.

**[0011]** Preferably, the heat pack further comprises a user actuated button adapted for engagement with the second end of the plunger. In particular, the heat pack may include an aperture through which the second end of the plunger projects and the user actuated button may be mounted to overlie the second end of the plunger and to close the aperture in the wall of the heat pack. Also, the user actuated button may bias the plunger in its first position.

**[0012]** Ideally, the initiation chamber is substantially centrally located within the heat-pack. A substantially rigid locating member may be used which connects the housing of the phase change initiator to the wall of the heat pack.

**[0013]** Also, the phase-change material may comprise a material selected from the group comprising: sodium acetate, sodium acetate trihydrate, lithium acetate dihydrate, calcium chloride dihydrate, calcium nitrate tetrahydrate, magnesium chloride hexahydrate, managanese sulphate hydrate and ferric chloride hexahydrate.

**[0014]** In a further aspect the present invention provides a feeding bottle for a baby which comprises a bottle; a feeding teat; and a heat pack as described above located between the feeding teat and the bottle, in the present invention the heat pack is located within the volume of the feeding teat. The heat pack is adapted to heat, upon initiation, the fluid flowing from the bottle to the nipple of the feeding teat.

**[0015]** The baby's feeding bottle may further comprise a heat pack cover wherein the space between the surface of the heat pack and the heat pack cover defines a fluid pathway from the bottle to the feeding teat.

**[0016]** Also, the baby's feeding bottle may further include a valve for controlling a flow of air into the bottle.

**[0017]** In the context of this document reference to an exothermic phase change material is to be understood as to be reference to a material which is thermodynamically unstable and is capable of undergoing a thermodynamic change of state arising from changes in its chemical structure. Reference to exothermic phase change materials is not intended to encompass materials which generate heat as a result of a chemical reaction resulting in changes to the composition of the material.

Brief Description of the Drawings

**[0018]** An embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates a heat pack with a phase change initiator in accordance with the present invention;

Fig. 2 is a partial sectional view of a heat pack adapted to warm a fluid which includes the phase change initiator of Fig. 1.

Description of an Embodiment of the Invention

**[0019]** In Fig. 1, a heat pack 10 containing an exothermic phase change material 20 and a phase change initiator 11 is shown. The phase change initiator 11 comprises a piston arrangement consisting of a cylinder 12 and a plunger 13. Both the cylinder 12 and the plunger 13 are preferably formed of a material which is substantially rigid, i.e. the material of the cylinder and the plunger does not flex under manually applied forces, for example non-reactive polypropylene. The cylinder 12 is closed at one end and its opposing end is closed by the plunger 13 which slides within the cylinder 12: the walls of the cylinder 12 being of sufficient length to accommodate the entire travel of the piston 13. The space within the cylinder, described by the walls of the cylinder 12 and a first end of the plunger 13, functions as an initiation chamber 18 and has a variable volume in dependence upon the position of the plunger 13 in the cylinder 12. The cylinder 12 has openings, which in Fig. 2 are slots 15, providing fluid communication for the phase change material 20 between the interior of the initiation chamber 18 and the exterior of the initiator 11.

**[0020]** The cylinder 12 is fixed in position within the heat pack 10 by means of a locating member 14. Like the cylinder 12, the locating member 14 is substantially rigid and capable of withstanding manually applied forces. Ideally, the cylinder 12 is positioned such that the end of the initiation chamber 18 furthest from the plunger 13 is located centrally within the heat pack 10.

**[0021]** The second end of the plunger 13, opposite to the first end located within the cylinder 12, projects through an aperture in the casing wall 10' of the heat pack and is aligned with a user actuated button 16 formed of a resilient material such as, but not limited to, a non-reactive thermoplastic elastomer (TPE) material. In the illustrated embodiment the second end of the plunger is connected to the user actuated button 16. The connection between the plunger 13 and the user actuated button 16 may be direct or indirect and may only occur when the button 16 is actuated. As illustrated in Fig. 1, the user actuated button 16 is provided on the exterior of the heat pack 10 and seals the aperture in the heat pack wall 10' through which the second end of the plunger 13 projects.

**[0022]** Thus, the plunger 13 extends from the user actuated button 16 to the cylinder 12. This arrangement allows a user to apply a force remotely from the initiation chamber 18, which is transmitted via the button 16 and the plunger 13 to the initiation chamber 18. Thus, when a user depresses the button 16 the applied force is transmitted to the plunger 13 which causes the plunger 13 to move so that the plunger slides within the cylinder reducing the volume of the initiation chamber 18. The effect of this reduction in volume is described in detail below. The resilience of the user actuated button 16 permits the button to deform under an applied force whilst still maintaining the seal over the aperture in the casing of the heat pack. This arrangement permits the casing to be substantially rigid i.e. non-deformable to manually applied forces.

**[0023]** As shown in Fig. 1 the initiation chamber 18 contains a plurality of small balls 19. Whilst there is no limit on the diameter of the balls, it is preferred that each ball has a diameter of between 1 mm and 10 mm, more preferably around 2.5 mm. The slots 15 in the cylinder 12 are dimensioned so as to permit the flow of phase change material but to prevent escape of the balls 19 from the initiation chamber 18. The balls are preferably formed from soda glass or another material which is resistant to deformation under manually applied forces and thus has a high Young's modulus, preferably in the range 40 GPa to 100 GPa, and more preferably greater than 60 GPa. The high Young's modulus of the material of the balls is required to maximise the transmission by the balls of compressive forces applied remotely by the user. Preferably the balls are of a non-ferromagnetic material, to allow the initiator to be placed in a microwave oven, without risk of electrical arcing.

**[0024]** When the first end of the plunger 13 is pushed towards the end of the cylinder 12, the resulting reduction in the volume of the initiation chamber 18 forces the balls 19 into close proximity with each other and in some cases the balls 19 may come into contact. The curvature of the balls 19 means that when the balls are in contact with one another the surface area of contact is very small relative to the total surface area of a ball, for example the radius of the contact area may be of the order of $6.2 \times 10^{-5}$ m. This means that the remotely applied force transmitted by the balls is focused onto a very small area of contact between the balls thereby generating a correspondingly large pressure in the contact region. The proposed arrangement is capable of developing pressures of the range of 1 kbar – 6 kbar (100 MPa to 600 MPa). This also means that even light manually applied pressure on the button 16, as little as 5 Newtons, results in a large pressure at the contact region between two balls 19 sufficient to trigger nucleation.

**[0025]** The region of ball contact experiencing the local high pressure provides a nucleation site which initiates a phase change in the exothermic phase change material within the initiation chamber 18. As the phase change material in the initiation chamber 18 is in communion with the phase change material outside the initiation chamber 18, via the slots 15, once initiated the phase change reaction spreads from the inside of the initiation chamber 18 throughout the volume of the heat pack 10. It will, of course, be apparent that usually there is not a single nucleation site but that as the volume of the initiation chamber 18 is reduced a plurality of nucleation sites may form simultaneously.

**[0026]** As a phase change reaction generally results in changes to the volume of the phase change material, the heat pack 10 also includes an expansion joint 17 (see Fig. 2). The expansion joint 17 is made of a resilient material, preferably in the shape of a disc to provide for an even distribution of forces. The expansion joint 17 may flex outwardly, away from the interior of the heat pack, to accommodate an increase in volume and / or may flex inwardly, towards the interior of the heat pack to accommodate a reduction in volume.

**[0027]** Ideally, the plunger 13 is provided with a biasing member (not illustrated) which biases the plunger 13 to a first position in which the initiation chamber has the maximum available volume. The biasing member may be a spring or other resilient member for example formed of a thermoplastic elastomer material. It will be apparent that the user actuated button may additional function as the biasing member for the plunger.

**[0028]** In Fig. 2 a baby's feeding bottle 30 is illustrated incorporating a heat pack 10, similar to the one described above. As can be seen, the heat pack 10 is mounted on top of a lower bottle 31 containing a fluid, such as milk, which is to be heated. A feeding teat 32 is provided on top of the heat pack 10 with a skirt 33 which overlies the exterior of the heat pack 10 and engages with the top of the bottle 31. The heat pack 10 has outwardly projecting fins 34 on its exterior which describe with the skirt of the feeding teat a labyrinthine fluid passage from the bottle 31 to the aperture in the feeding teat 32. Thus, heat generated by the heat pack 10 is thermally conducted via the outer casing of the heat pack and the fins 34 to any fluid flowing within the labyrinthine fluid passage. Although not shown, it is envisaged that a valve for admitting air into the bottle 31 would be employed.

**[0029]** Unlike Fig. 1, in Fig. 2 the locating member 14 is attached close to the inner apex of the heat pack 10 and the phase change initiator 11 is suspended by the locating member 14 below the inner apex.

**[0030]** Although the phase change initiator is described above in relation to a heat pack employed as part of a self-heating baby's feeding bottle, it will be apparent that there are many other applications for the phase change initiator. For example, the heat pack of Fig. 2 with its labyrinthine fluid path may be used with other beverages which would normally be drunk hot such as coffee and also in relation to other fluid foods such as soup. Also, the phase change initiator can be used for heat packs that are use to heat fluids other than foodstuffs such as cosmetics, adhesives and oils and is suitable for use as a latent heat battery for use in vehicles at start-up. The use of the heat pack in relation to such non-foodstuffs is particularly beneficial where the non-foodstuffs tend to flow more freely when warmed. It is further envisaged that the heat pack may be used in medical applications for example as a muscle relaxant. Also the heat pack of Fig. 2 with its labyrinthine fluid path may be used to warm fluids which are to be injected or transfused into a human or animal body. In particular, it is envisaged that the heat pack of the present invention may be used as an alternative to the blood warmers currently in use.

**[0031]** Heat packs having the phase change initiator have applications in addition to heating fluids. For example, the heat pack may be used as a pocket/hand warmer and in other circumstances where a temporary source of heat is required, e.g. in an incubator or food hamper.

**[0032]** It will, of course, be appreciated that whilst the engagement of the plunger in the cylinder is required to provide a sliding fit, the plunger is not required to form a fluid seal with the cylinder. Indeed, it is preferred that the sliding fit of the plunger in the cylinder permits fluid to flow between the plunger and the wall of the cylinder. Moreover, the present invention is not limited to the specific features of the phase change initiator and the heat pack describe herein. For example, the slots 15 may take any form as along as they provide fluid communication between the interior and exterior of the initiation chamber. Similarly, the balls 19 are not required to be spherical. Instead, any granular material or combination of granular materials having a curved or irregular surface and which provides only a small contact region when two grains come into contact and which includes interstices in the surface which are smaller than the contact area is envisaged. Other changes to the features of the phase change initiator and the heat pack described herein are also envisaged without departing from the scope of the invention as claimed.

## CLAIMS

1. A phase change initiator for use with an exothermic phase change material comprising a housing having an initiation chamber therein containing a plurality of grains, the housing having one or more openings dimensioned to retain said grains in said initiation chamber and to allow fluid communion between the interior and the exterior of the initiation chamber, said phase change initiator being characterised by the housing being substantially rigid and by the phase change initiator further comprising a plunger, a first end of the plunger being slidably received in the initiation chamber and a second end of the plunger, remote from the first end of the plunger, being adapted for manual operation.

2. A phase change initiator as claimed in claim 1, wherein the one or more grains have a Young's modulus of between 40 GPa and 100 GPa.

3. A phase change initiator as claimed in any preceding claim, wherein the one or more granular materials are formed of soda glass.

4. A phase change initiator as claimed in any one of the preceding claims, wherein each of the plurality of grains is spherical.

5. A phase change initiator as claimed in claim 5, wherein the grains have a diameter of between 1 mm and 10 mm.

6. A phase change initiator as claimed in claim 6, wherein the grains have a diameter of 2.5mm.

7. A phase change initiator as claimed in any preceding claim, wherein the plunger is biased towards a first position of maximum volume in the initiation chamber.

8. A heat pack comprising a substantially rigid casing containing a phase change initiator as claimed in any one of claims 1 to 7 and an exothermic phase change material, the phase change initiator being operable for activating a phase change of the exothermic phase change material within the casing.

9. The heat pack of claim 8, further comprising a user actuated button on the casing adapted for engagement with the second end of the plunger.

10. The heat pack of claim 9, wherein the casing includes an aperture through which the second end of the plunger projects and the user actuated button is mounted to overlie the second end of the plunger and to close the aperture in the casing.

11. The heat pack of claim 10, when dependent upon claim 7, wherein the user actuated button biases the plunger in its first position.

12. The heat pack of any one of claims 8 to 11, wherein the initiation chamber is substantially centrally located within the heat-pack.

13. The heat pack of any one of claims 8 to 12, further comprising a substantially rigid locating member which connects the housing of the phase change initiator to the casing.

14. The heat-pack of any one of claims 10 to 13, wherein the phase-change material comprises a material taken from the group

comprising: sodium acetate, sodium acetate trihydrate, lithium acetate dihydrate, calcium chloride dihydrate, calcium nitrate tetrahydrate, magnesium chloride hexahydrate, managanese sulphate hydrate and ferric chloride hexahydrate.

15. A baby's feeding bottle comprising a bottle; a feeding teat; and a heat pack as claimed in any one of claims 8 to 14 located between the feeding teat and the bottle and adapted to heat, upon initiation, fluid flowing from the bottle to the feeding teat.

16. A baby's feeding bottle as claimed in claim 15 further comprising a heat pack cover wherein the space between the surface of the heat pack and the heat pack cover defines a fluid pathway from the bottle to the feeding teat.

17. A baby's feeding bottle as claimed in either of claims 15 or 16 further including a valve for controlling a flow of air into the bottle.

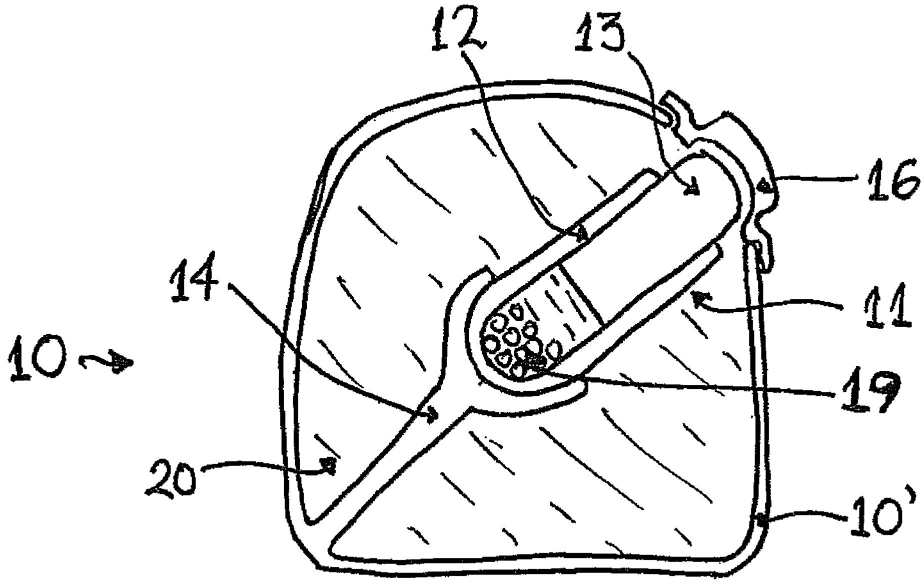


Fig. 1

Fig.2.