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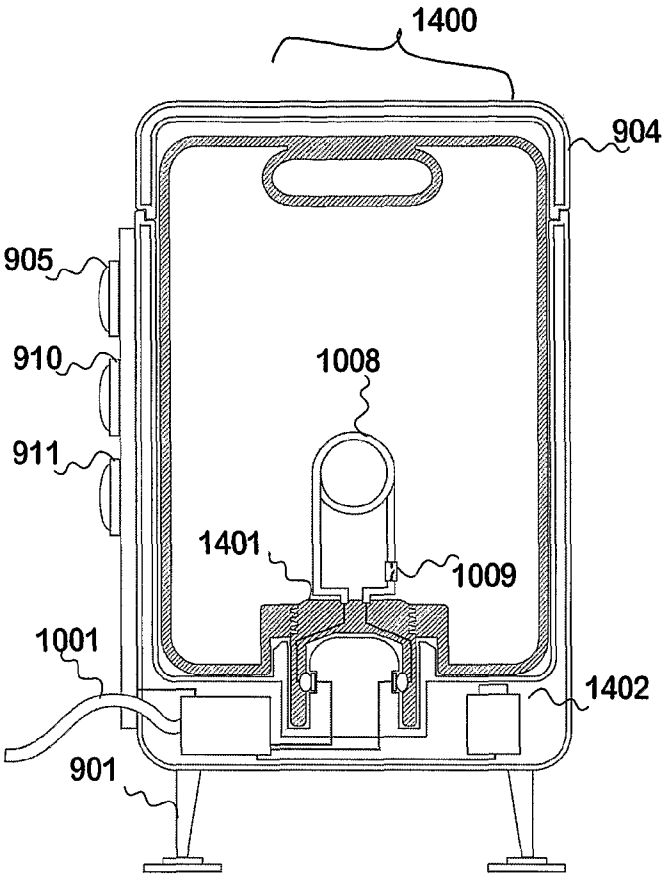
(54) Title: ENERGY-EFFICIENT BED WARMERS



(57) Abstract: A bed-warming system includes at least one reheating station that electrically heats compatible personal heating units to a safe temperature. Direct connection or inductive power transfer methods are preferred. Latent heat evolution at for example about 45 deg C from capsules holding a wax inside each heating unit simulates a higher effective specific heat than water alone, and at a steady temperature. A high effective heat is alternatively simulated by use of an battery within a personal heating unit that has been recharged, then discharged through a heater inside the module under electronic temperature-regulated control.

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Energy-efficient bed warmers

This invention relates to a bedside bed-warming means somewhat like the hot water bottle

BACKGROUND

This invention relates to bed-warming devices that use portable modules that receive energy, and then deliver that energy to the local environment as heat. A well-known version of this sort of device is the domestic hot-water bottle which evolved from bedpans containing hot coals once rubber bottle technology was developed. Hot-water bottles have a number of disadvantages including: (1) the amount of heat stored is good for perhaps two or three hours only and drops continuously during use so encouraging people to start at too high a temperature, (2) the initially filled hot water bottle is capable of causing tissue damage by overheating body parts in contact, especially if used with elderly or unconscious persons, (3) the process of filling a hot-water bottle with hot water often results in spilt hot water, while air rushes out of the bottle during filling, causing pain or scalding to the person filling the bottle, (4) the water heated for use is mostly wasted, and (5) the above aspects of conventional hot-water bottles are inconsistent with energy and water conservation which have become much more important in recent times. The inventor expects that rises in the cost of energy will tend to encourage the use of hot-water bottles and analogous devices as opposed to whole-house heating, along with thermally insulating clothing, coverings and bedding.

DEFINITIONS

"Portable heating means" refers to an analogue of a hot water bottle, modified to be used as part of the invention.

"Rewarming station" refers to a closable cabinet within a bed heating system, each station including a separately temperature-regulated energy supply for rewarming a portable heating means.

"Bed heating system" refers to a combination of at least one rewarming station and a supply of the

portable heating means. This is usually a bedside appliance but may be used in an institution providing bed care to a number of people, with perhaps 6-12 individual reheating stations..

"Effective Specific Heat "describes the amount of heat output required to cause unit mass of a substance to fall from a first to a second temperature and if that fall includes a change of state then the descriptor includes the amount of heat evolved during a change of state. For a battery-driven version, the "change of state" is the discharging of the battery from a fully charged to a fully discharged state. The heat evolved is measured, as is the weight of the battery and associated electrical devices; active or pasive, used to extract the heat. The term also includes "normal" specific heat of substances where no change of state is involved.

PRIOR ART

Schnoor in US 2004/0102823 describes a flat bag, holding a mixture of vegetable oil and paraffin wax, for use as a heating pad. Noppel et al in US 5069208 describe a cooling or heating pad including cells containing material that can change state and take in or supply latent heat. Feback et al in US 6615906 describe a "latent heat body" somewhat optimised to store latent heat but without focus on heating pads for bed warmer use. Boys in US 5450305 describes a variety of suitable induction-heating power supplies. (see Fig 6 herein).

OBJECT

It is an object of this invention to provide improved apparatus for bed-warming purposes, or at least to provide the public with a useful choice.

STATEMENT OF INVENTION

In a first broad aspect this invention provides a bedside system or bed-warming device including at least one rewarming station each capable of re-warming a portable, sealed heat source herein called a "portable heating means" capable of releasing heat during use though constrained to release it at no more than a predetermined, safe temperature, wherein the electrically powered heating element is contained within the container of the portable heating unit, and further includes thermally responsive interruption means capable of deactivating said heating element when the fluid mass in

the container exceeds a first given temperature greater than 90 degrees Celsius..

Preferably a cold portable heat source is placed inside the station and left to reach an operating temperature.

Preferably said rewarming station includes a heat sensor arranged to detect a temperature of said portable heating unit when the two parts of the two-part connector are engaged together, and a switch by which said means to supply electrical power to said heating element can be deactivated, said switch being operable when a temperature detected by said heat sensor exceeds a second, selected temperature.

Optionally said heat sensor includes means for interpreting infrared radiation received from said portable heating unit as a temperature.

In one option for power transfer, said rewarming station includes at least one chamber each shaped and dimensioned to receive and hold one portable heating unit, each two-part connector comprises a socket and complementary peg each including electrical contact means, the socket being provided at an end of said portable heating unit and the peg being provided as a projection inside said chamber of the rewarming station, so that power from within the rewarming station can pass through the electrically powered heating element inside the personal heating unit.

Optionally said rewarming station includes sensor means to detect the presence of the portable heating unit in said chamber, and includes means to permit the supply power to said heating element only when the portable heating unit is detected in said chamber.

In a related aspect, the heat-retaining fluid mass in the portable heating unit is comprised at least in part of water.

Preferably the heat-retaining fluid mass in said portable heating unit comprises a plurality of envelopes filled with a meltable material forming filled cells, and a fluid for transporting heat about the contents selected from a range including water and oil.

Preferably, the fluid mass has an effective specific heat at least about the same as for water. (Equivalent: 0.238 kJ/kg per degree C).

In one option, the latent heat properties of selected materials are employed in order to extend the

duration of supply of heat from a given mass at a medically safe temperature.

Preferably each particle of said particulate solids is comprised of a non-toxic encapsulated substance having a melting point of between 45°C and 95°C.

In another option for power transfer (inductive power), said rewarming station includes a power-supply unit having means for connecting to an electrical power supply and means for creating electrical energy transmissible without wires and coupling said energy into a connector-less portable heating unit; the portable heating unit comprising a sealable flexible container containing a heat-retaining fluid mass; the mass including energy-capturing means capable of capturing oscillating electrical energy received from the power-supply unit and of converting said energy into heat within said fluid mass.

Preferably, the heating element comprises a resistive wire coil as a closed loop in said container, and the means to supply electrical power to said heating element comprises an induction coil in said power supply unit, positioned and arranged to induce a current in said resistive coil when the two parts of said two-part connector are in proximity.

Optionally the closed loop includes a tuning capacitor so that the closed loop may serve as a resonant secondary winding, in which case the thermally actuated switching means may act to destroy resonance.

Preferably the inductive power transfer is carried out at a frequency of over 20 kHz.

In another option for power transfer (microwave energy), the energy-capturing means comprises water, and the means to supply electrical energy to said energy-capturing means comprises a generator of electromagnetic energy having a frequency such that the energy is capable of effective absorbtion by water, positioned and arranged to cause the water to become heated when the generator is in use.

Preferably the heating system of such options includes sensor means for sensing the temperature of the portable heating unit; the sensor means being operatively connected to cutoff means capable of limiting the supply of energy to said portable heating unit so that said portable heating unit cannot be heated beyond a predetermined temperature.

Preferably, said power supply unit includes sensor means to detect a presence of the portable heating

unit in said chamber, and includes means to permit the supply power to said heating element only when the portable heating unit is in place within said chamber.

A heating system, characterised in that the heating system includes: a rewarming unit having means for connecting to an electrical power supply and means for transferring electrical energy into a rechargeable battery contained within a portable heating unit; the portable heating unit comprising a sealable flexible container containing activatable means for converting the energy within the battery.

Preferably the presence of internal metal items prevents the personal heating unitr from being heated to an unsafe temperature in a microwave oven.

In yet another option for power storage, the sealed bed warmer includes electrochemical reversible storage means comprising at least one rechargeable battery and means for controllably discharging said battery through an included resistance so as to maintain the sealed bed warmer at or about a predetermined temperature, using an associated temperature sensor and control means..

Preferably the sealed bed warmer includes a loop of wire capable of serving both as an inductive power transfer pickup, as previously described in this section, during charging of the battery, and as a heat dissipating device during discharge, so that the sealed bed warmer may be (re)loaded from the exterior without physical contact.

Alternatively a direct electrical connection can be used during charging of the battery

In one option a charged bed warmer according to the fourth version is provided with externally accessible control means that is capable of switching off the charged bed warmer until required.

PREFERRED EMBODIMENT

The description of the invention to be provided herein is given purely by way of example and is not to be taken in any way as limiting the scope or extent of the invention.

Throughout this specification unless the text requires otherwise, the word "comprise" and variations such as "comprising" or "comprises" will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

DRAWINGS

Fig 1: is a diagram showing a sealed hot water bottle (portable heat source) having a fill including cells holding material having desired latent heat properties.

Fig 2: is a diagram showing an unsealed (closable) hot water bottle including cells holding material having desired latent heat properties.

Fig 3: shows a sealed hot water bottle (portable heat source) including within the fill a closed loop of wire.

Fig 4: shows a closed loop of wire with series components including a thermal cutout.

Fig 5: shows an open loop of wire with external electrical connections and a thermal cutout.

Fig 6: shows a prior-art (Boys) inductive heating circuit having a resonant primary loop 10b (provided by way of example).

Fig 7: shows a cross-section through a re-heating bedside unit including (in this embodiment) an inductive heating power supply.

Fig 8: is a block diagram of a bed warmer employing a rechargeable battery as a source of energy.

Fig 9: is a perspective view of one embodiment of an actual bedside unit.

Fig 10: is a simplified circuit diagram for a rewarming station, for a bed warmer using resistive heating.

Fig 11: Shows a multiple rewarming station for bed-warmers.

Fig 12: is a bedwarmer suitable for use with reheaters of Figs 11 and 14..

Fig 13: is an outline through a rewarming station

Fig 14: is an outline through a rewarming station with a bedwarmer in place, for reheating.

There is an overall desire to economically provide an easily replenishable bed-warming module or portable heat source that delivers heat at a safe temperature in a convenient and safe manner as a substitute for the well-known rubber hot water bottle. Many people prefer the "feel" of a hot water bottle over the more expensive to run central heating or the feel of an electric blanket. Some ways to exploit Effective Specific Heat held by a mass are:-

1. Use of specific heat of water or similar (reversible). The specific heat of water is 0.238 kJ/kg per degree, hence a 30 degree fall in temperature releases about 7.14 kJ per kilogram. (Examples 1, 1A, 1B)

2. Use of latent heat of e.g. solidifying wax or other suitable material (reversible). The Effective Specific Heat, if just the latent heat is exploited, is (for paraffin wax) about 60 kJ/kg which is about eight times better than water alone. (The Effective Specific Heat is clearly higher than that for water but that particular example of paraffin wax has a rather high melting point).

3. Use of heat evolved by a chemical reaction (not reversible, possibly dangerous, justified for search and rescue or military applications, rather than in domestic areas.) For example the burning of paraffin wax releases about 42,000 kJ/kg although not all of that heat would be captured under a controlled burning process.

4. Conversion of stored electricity into heat (using a battery that is preferably, but not necessarily, rechargeable). The specific energy of a fully charged Ni-Cd battery is about 45 kJ/kg and newer types of battery such as lithium can store several times that amount. A Ni-Cd battery can be fully charged and then discharged perhaps 700-1000 times in its life and electronic control of the heat output gives a safe and controllable mode of usage. The power may be dissipated as heat within a portable heat source containing a battery, or carried by connecting wires to warmed clothing. All possible inefficiencies during discharge (such as within semiconductors) are converted to heat and are captured as useful output in this application. The "bed feel" problems of a hot water bottle analogue containing palpable hard lumps may be overcome.

Exploitation of examples 1, 2, and 4 must also consider ways to "load" a personal heating unit with heat or energy.

5. Externally heated water is briefly considered in conjunction with retained capsules filled with a wax or other substance exhibiting a state change at a useful temperature, held within an unsealed flexible container.

6. Electricity introduced into a sealed flexible bag and there used to heat either water or a mixture of water and substance-filled capsules, or to charge a battery is considered.

7. Microwave or similar energy which can be absorbed by water but substantially not by the walls of a sealed flexible bag and therein used to heat water or water with substance-filled capsules is

considered.

EXAMPLE 1

Fig 1 shows a bed warmer or portable heating means comprising a rubber or other flexible envelope (such as polyvinyl chloride (PVC) plastics with plasticiser) 100, having a handle 102 and a hollow interior filled with capsules or cells 101 each cell holding an amount of paraffin wax (or other latent heat-effective material), separated by water (or an oil) which serves to redistribute the heat. Without being packed into capsules, the paraffin wax will tend to congeal into a single mass which is unpleasant to feel and harder to heat. This portable heat source may alternatively be heated by thermal contact or by microwave energy but in such cases there is no inherent protection against overheating. (PVC and microwaves are not very compatible since microwaves do heat the plasti itself). To start with the external appearance of the invention as put in practice, Fig 9 shows the appearance of a finished bedside unit or rewarming station 900, including support legs 901, two reheating stations (902, 903) each with a lid 904, and a control panel 905 including, in this example (from top), a timer, a temperature control (which may prove incompatible with safety requirements), and power level control means to charge the portable heat source more quickly. The power cord 907 is also visible. A lifting handle (906) of one portable heat source is also shown. The outer case 908 is thermally screened, preferably electrically earthed, and if necessary, electromagnetically screened. Similar units could be made to be mounted under a shelfor in other convenient places. A corresponding portable heat source (hot water bottle) is shown in Fig 12 at 1200; the majority of the surface 1201 being waterproof, flexible, and may have a relatively low thermal conductivity (like a hot water bottle cloaked in a knitted woollen cover) and this example includes a special connector 1202. Fig 11 shows an institutional version of a rewarming station 1100, configured for mounting on a wall. 1101 is one of nine closable lids, each bearing an example control panel 1102 with indicator lights to show when the contents are up to the predetermined temperature. One portable heat source 906 is shown emerging from an opened lid at 906.

This invention relates to a bedside system relying on portable heat sources each of which comprises a mass having a high effective specific heat, at least as high as water, as exhibited at a preferred working temperature of at most about 45-65 deg C (the priority being, of course, not to provide a dangerously hot bed-warmer in contact with a person. Scalds and burns can be produced. The threshold of normal subjects for pain from hot objects is at about 52 deg C, at which temperature protein degradation commences, so a bed warming device should not be used at or over this

temperature. Furthermore, the poor peripheral circulation of some persons including diabetes patients raises the risk of tissue damage with bed warmers at even under 45 deg C and many hospitals and care providers simply will not use hot water bottles at all. The inventor accepts that temperature selection is the domain of medical care experts and simply provides a personal contact heating system, the maximum temperature of which can be adjusted to an accurate [redetermined value which, it is hoped, will lower some of the barriers to the use of hot water bottles. The means for adjustment may be concealed from unauthorised access. People in good health may not need any low-temperature safety provisions and may be able to use personal heating units at near-boiling temperatures, especially if in low-conductivity jackets..

For raising the "effective specific heat" as herein defined, we prefer a "wax" as an example material that melts or freezes in the desired range at normal pressures. Preferred materials will be non-toxic, non-allergenic, non-reactive and generally safe and acceptable, and will preferably exhibit a large latent heat of melting/freezing (which is, of course, reversible) in terms of joules per kilogram. Different waxes may be mixed together to approximate a desired melting temperature although the sharpness of the melting point may be lost. Apart from common waxes such as paraffin (hydrocarbon) or bee's wax there are other acceptable materials including various plastics or resins which are hereby imported into the ambit of the invention. For example, the components of at least some types of "hot glues", or chemical modifications thereof, are or can be made suitable. Eutectic mixtures of metal salts also have latent heat properties; this specification embraces all materials having like properties. On reduction of temperature (as when in use) the temperature of the portable heat source usefully remains fairly constant for a period, while the wax gradually freezes and latent heat is evolved, thereby providing a high effective specific heat over a limited range. Paraffin wax or the like is a potentially combustible material if it escapes, but is otherwise not dangerous or toxic.

In this Example, a rubber (or equivalent waterproof flexible material) portable heat source reasonably similar in external appearance, weight, and other characteristics to existing water-filled hot water bottles is provided in a sealed configuration containing (a) water holding in free suspension (b) a plurality of closed capsules or cells of a mixture of wax and (c) an optional air pocket, each cell having a volume of perhaps about 1 ml so that the user feel of the hot water bottle is reasonably similar to that of existing water-filled hot water bottles. The water is provided as a heat transfer medium for capsules containing wax, or as a material having latent heat in its own right. The use of cells is preferred so that the wax does not congeal as one solid lump as would happen without use of cells. Each cell may comprise a sealed sphere or cube or similar shape,

containing the active material. A long sealed tube filled with wax may be pushed into the interior of the bottle. The heat diffusion distance into the centre of any one cell is small, so that the overall temperature response is relatively rapid. An oil could be substituted for the water. A partially insulating jacket made for example of a woollen or polyester fabric may be provided over the outer rubber (or like) surface of the hot water bottle in order to extend its operating (cooling) period, reduce inherent danger of tissue damage, improve the "feel", and make it impractical to overheat the hot water bottle by immersion in a container of hot water. A cell or capsule holding wax as intended for use herein in large numbers can be made for example by heat-sealing a pellet of wax into a polyethylene tube to form short packets (cells) holding wax, which may be separated apart or remain in the form of a segmented tube.

The cooling behaviour of an Example 1 portable heat source during release of heat is as follows:

1. The temperature of the heated bottle falls at a steady rate dependent on the overall specific heat and amount of the mixed water and suspended closed blisters of frozen wax until...
2. the wax starts to freeze at its melting point, whereupon the temperature of the portable heat source remains relatively constant for a period while the latent heat is released, until ...
3. all the wax has frozen, whereupon the temperature of the portable heat source falls again.

Fig 2 shows a variant portable heat source again employing the fill of wax capsules but in contrast to the dominant theme of this invention allowing conventional addition of hot water from an external supply through a funnel 201 and removable seal 202 in order to add heat in a relatively uncontrolled manner to the bed warmer. A sieve 203 prevents escape of the cells holding wax during emptying. It may be found that several replacements of hot water are required in order to cause sufficient wax to melt, and then the heated bed warmer has the advantage that it will last longer in use than a water-only version. Clearly, this option undoes several of the advantages (such as no splashing or water waste) of the invention cited elsewhere in this specification, but does teach another, low-technology method of putting energy into the portable heat source.

Figs 9 to 14 show a way for bringing electric current into the portable heat source during a rewarming process by electrical connection at a "female" part of each connector pair that is placed at an end (or side) of the portable heat source.The current rating of these connectors should be 2 to 5 A, since local heating would heat up the rubber neck quickly. Good contact can be assured by means well known to those skilled in the art, such as gold flashing over contact surfaces, use of the resilience of the rubber neck to assure a good grip, and possibly magnets conealed within each side

that pull the contacts together. The male part is recessed within an open cylindrical or oval neck 1202 like that of conventional hot-water bottles and comprises a pair of facing connector surfaces 1007A, 1007 which are wired within the head assembly (cross-section Fig 14-1401) to leads-ins to an electric heatable element 1008. This assembly is preferably, though not necessarily rigid. Since it may be smaller than shown in Fig 14, it is not likely to affect user perception. Size is related to an acceptable rewarming time. The element includes at least one thermal reclosable fuse 1009 which may comprise the only temperature limiting device in a simple circuit, or which may be a backstop in a more complex circuit. It is also a backstop in the even of unauthorised direct connections to the mains. The sealed personal heating unil should not be made to boil. Fig 14 shows that one benefit of the orientation as shown here and in Fig 9 is that fluid within the personal heating unit will tend to flow down and cover the element. Use of a big heating station as shown in Fig 9, rather than simply a connector on an end of a cord, has the particular advantage that people cannot easily bring the charging or reheating means into bed.

The corresponding "male" part of the connector is shown in Fig 13 and comprises a protruding round or oval object 1007, 1007A deep within the heating station. Safety is enhanced by distance separation of each contact and by use of a lid interlock so that no power is applied to the connector if the lid is open. A connector like those used on cordless kitchen appliances may be substituted for the one described.

Direct mains heating has advantages and disadvantages. There is a perceived raised safety risk as compared to for example 12 volt systems, and any design using this idea must use common sense as well as adhering to applicable standards and regulations. On the other hand it is easy to control a mains AC current using semiconductor devices, and use of a residual-current detector is generally considered appropriate as a sufficient safety measure. A higher connector current, such as 23 Amps 10 volts (equivalent power to 1 amp 230 volts) places much greater requirements on connector design. Use of a simple step-down transformer rated at 250 VA has a cost and a weight penalty of some kilograms. Again, note that the voltage is simply not present when the personal heating unit is giving out heat.

It is desirable that the electric current connections be protected from unauthorised user modification. The inventor thinks that having portable heat sources heated or recharged by non-approved means (especially with mains electricity) is dangerous. Electrocution, steam explosions, and scalding of end-users can happen. In that respect, presence of metal components within the sealed container should prevent this device from being heated in a micrwave oven. The electrical connectors might

be disguised as something else (such as brass edging around the bed warmer) yet still remain usable by the purpose-designed heating unit. Safety interlocks may be used. It is clear that once a resistively heated bed warmer of this type is disconnected from the heating current, it immediately becomes electrically quiescent and electrically safe for use in a bed even if there are one or more exposed connectors. Reference to 12 volts is made in part because this bed heating system may be run from a 12 volt storage battery kept charged by sustainable energy. Other voltages, such as 110 or 220 volts may be less demanding of connector capacity; yet more demanding of wire insulation.

The active components (wax-filled cells, wire coil, water, or the head assembly 1401 of fig 14) may be supplied for assembly pre-packed in a bladder 302 such as a sealed plastic bag ready to be inserted into a sealed rubber (or the like) exterior bag, useful if a rubber goods factory making portable heat sources is separate from another factory making the electric components.

Figs 3, 4 and 5 show use of induction another, connector-free way of bringing electric current into the portable heat source during a rewarming process, for conversion into heat by conventional means such as by passing the high-frequency AC secondary current through an internal, immersed heating wire loop 301 having a resistance. (Preferably this wire is lightly yet effectively insulated in order to protect against corrosion, shorting, or electrolytic effects). For example, if a 12 volt DC supply was connected to an internal coil of wire having a 1 ohm total resistance then 144 watts of heat would be generated within the wire by the 12 amperes flowing, and this would soon warm a thermally enclosed bed warmer.

In Fig 3, a portable heat source 100 (as per Fig 1) is shown including a closed loop of wire 301 - the secondary winding - that may be supplied with electricity by inductive power transfer (also see Figs 4, 6 and 7). In Fig 4, the closed loop of wire is depicted with a series-connected thermal cutout device 402, which is preferably a switch that opens if the surrounding temperature exceeds a predetermined level such as 46-80 deg C. The switch would close again when the temperature drops by 5 deg C for example, so that if the bed warmer was held within an activated rewarming unit it would hold its temperature until taken out for use. (If the switch cannot reliably switch the heating current, it may be separately connected through extra contacts in the connector to a control input of the heating supply so that its contacts do not carry a heavy current. An equivalent for possible substitution is a PTC rod thermistor device is known, with characteristics compatible with mains voltages, that can carry the heavy heating current when cold, but when hot its resistance rises so much that only a small current flows through the heating element. This device is used immersed but insulated from the fluid inside the personal heating unit. And, an internal thermistor may be

connected in that manner. In that case it may be a thermistor, not a switch). Fig 4 also shows an optional tuning capacitor 401 which has the effect of making the wire loop a resonant secondary at the intended frequency, and thereby enhancing the transfer of inductive power by increasing the maximum current. The capacitor is incompatible with direct current heating and would not be used in a Fig 5 embodiment. When in use, significant resonant current flows in the coil causing ohmic losses in the wire itself (including skin effect, if high frequency currents exist) that results in heating of the surrounding water and hence the wax inside the blisters.

Inductive power transfer techniques, using a circuit such as the prior-art example shown in Fig 6, results in the formation of an alternating magnetic field at perhaps 25 to 50 kHz that is generated inside a rewarming station (Fig 7). The alternating magnetic field that is radiated from the coil 10b passes through the bed warmer walls and intersects the coil 301 inside the bed warmer, generating electricity within the coil and having the effect of moving energy into the warming module. This technique has the advantage that no metal parts traverse the wall of the warming module which may be a rubber bag as used in conventional hot water bottles, but is permanently sealed. There is no need to ensure that a physical electrical connection occurs. In addition, users cannot maliciously tamper with the rewarming station or the bed warmer such as to overheat it because they have no electrical connections to access. Fig 6 shows an example inductive heating power supply circuit and this prior art circuit will be described by way of example. 15B represents a DC power source. 12B and 14 are high-inductance coils used to supply current to the resonant circuit, made up of capacitor 13b and inductance 10b (shown in section as "OOO" and "XXX" in Fig 7). Either side of the resonant circuit is connected to the return supply of the power source alternately, at or about the resonant frequency of the circuit, through power switching devices 18b and 18b', which are activated as required by controller 19b.

A circuit of this type can be adapted for the present application such as by including a load detector, having the effect of switching the circuit off unless a secondary winding is present within the space covered by a field generated in the primary winding, and can be provided with 24-hour timing circuits as previously mentioned. In the section through an inductive heating station in Fig 7, the lid 701 should be connected to a switch to turn off the primary circuit whenever the lid is open. The exterior of the bedside system 700 should preferably include a metal so that the inductive fields do not leak out of the box whenin use, which is both inefficient and may give rise to safety issues. At the same time the box walls should have good thermal insulation properties, also to increase efficiency. Another safety device is one to sense the weight of the portable heat source presently

inserted. If the weight is zero, or below a predetermined weight, (such as if the portable heat source has lost some or all of its fluid), the heating circuit is disabled.

Therefore a rewarming station (bedside device) comprises part of the overall invention and would be physically and electrically matched to the warming modules (portable heating means). Externally, the rewarming station (see section 700 in Fig 7, or Fig 9 for an outside perspective view) would appear similar in all embodiments and would contain one or two pockets (rewarming stations) 902, 903 for holding portable heating means 100/900, and energy supply means (e.g. primary winding 10b) or contacts to the heating wires or element within the personal heating unit. Yet another approach is to simply heat the interior of the rewarming station for conductive transfer of heat into the heating the bed warmers by contact when placed inside the pockets. That may be too slow a process.

A typical rewarming station is located by a person's bed and would restore the energy within a bed warmer in about 5 to 30 minutes, whereupon the person can lift the protective lid 701 and remove a bed warmer. Through the night, if one bed warmer goes cold, the person would reach into the box, remove the other one, and put the cold one back. Termination of replenishment can be controlled electronically such as by sensing battery charge amount, or internal temperature. Two stations provide for a double bed, for example. Many rewarming stations might be used in an installation in a rest home, as shown in Fig 11.

Each portable heating means should preferably control its own heating process. A portable heating means can be left inside the charger until it is needed, where it will be raised or topped up to the intended maximum temperature from time to time. Charging is always halted once the portable heating means in the charger is hot enough, as determined at least by the thermal cutout device. The primary circuit may be arranged to charge up two "bottles" in adjoining compartments, so that one portable heating means can be re-warmed while the other is in use.

For a conventionally operated rewarming station, the inventor prefers to provide each portable heating means with an internal, conventional, mains-operated "element" or thermally conductive looped pipe carrying a heating means, such as a spiral of resistance wire within, preferably embedded in a thermally resistant unsulation, as is used in electric kettles for example.

Fig 10 shows a preferred circuit 1000. Alternating-current mains connectors 1001 are at the left, as is an earth return 1002. Block 1003 could be a step-down transformer or more preferably is a

conventional residual-current detector (RCD). In the event of leakage of electricity to the earth line, the imbalance of current flow in the RCD causes the device to interrupt the flow of mains current. Item 1006 is a conventional silicon -controlled switch or Triac rated to handle the load imposed by the cold resistance of heating element 1008. An electromechanical relay is an option for 1006. The heating element resistance is determined by considering a desirable time to reach a desired temperature, ascertaining the rate of power dissipation required, and applying Ohm's law as P = V*V/R. In this drawing and embodiment, the element 1008 and the thermal cutout 1009 are contained within the bed-warmer itself. Block 1005 generates a phase-synchronised gate current to render the Triac conductive as required.

Block 1004, for which power supply reduction and DC conversion means are not shown, is a control unit. Its complexity is dependent on the functions required of any particular version of the warming station. Inputs and indicator lamps are connected to the interface wires 1012. A smattering of safety devices are described, and further safety devices may be mandated by electrical safety organisations such as the Underwriters Laboratories or the like. Functions sorted by sophistication include, starting with the basic level:

1. Switching off the Triac whenever a user is accessing a personal heating unit or bottle, as detected by a sensor attached to the lid or hinge, detects an "open" state. (which could be done with a directly linked switch). That, with a PTC rod thermistor, may be the simplest option.

2. Switching off the Triac whenever the space for holding a heating unit is not occupied by a heating unit. Weight may be sensed. (This would detect a personal heating unit that has lost water).

3. Providing heat for a predetermined time, as determined by an about ten-minute timer and optionally, thereafter providing short bursts of "top-up heat".

4. Maintaining a 24-hour clock and bringing a personal heating unit up to an operating temperature at a particular time.

5. Heating a bottle at a variable rate such as "half-speed".

6. Responding to the output of a device measuring the current temperature of the personal heating unit, so that the heating element is provided with power only if the present temperature is below a predetermined level. The oopersting limits may be physiologically determined and may reflect the medical status of the person for whom it is being heated. For example one has to be particularly

careful not to burn the body of a comatose person. (One preferred means for measuring temperature during the reheating process is to use, at each warming station, an infra-red thermometer (using a Melexis MLX90614 device, for example: Melexis, Concord, NH, USA)) based on a thermocouple principle, which "looks at" the bed warmer being warmed and provides an accurate indication of temperature even if the bag is covered with a "woollen jacket" but is enclosed. The internal thermal switch should be retained as a backup or safety device for preventing overheating, since if a bed warmer was inadvertently heated to boiling point it would probably explode. (Hence a relief valve may also be preferred as a safety measure).

Not all of these functions may be provided in a "low-cost" option. It appears that a suitably programmed microprocessor would be one suitable device to use within block 1004. Wire pairs such as 1012 may be run to safety sensors, control buttons or switches, and a numeric or alpha-numeric display device That display may be used for displaying the time of day as a default activity. Circuit details are those well-known to persons skilled in the art of programming a microprocessor.(A digital clock/alarm chip may be used as one alternative for 1004).

For an induction heating option, the output of circuit at 1007/1007A may be used as a supply for a circuit such as that of Fig 6.

EXAMPLE 2 (electrochemical)

Rather than use a bulk property of latent heat of a selected material or mixture, a bed-warmer module externally visually similar to that of the preceding example(s) emulates a mass having a high effective specific heat by using electric batteries, which can store effective amounts of energy. The amount of energy storage available per unit weight is at least as good as a wax. New nickel metal hydride, or lithium rechargeable batteries are effective. (Consider how hot a laptop computer becomes, when operating from its battery supply while on one's knees). The Example 2 module uses a rechargeable battery as a store of energy and uses one or more active electronic modules to maintain a user-compatible heating surface at a predetermined temperature. The heating surface is heated by controlled current from the battery as long as there is energy in the battery. Preferably each electronic module has at least one of these features:

1. adjustable for temperature, within a safe upper limit (also, high temperatures tend to reduce battery life)

2. reliable / fail-safe) and perhaps the temperature transducer is internal to an integrated circuit in order to minimise parts count and wire breakages,

3. fail-safe - using PTC thermistor sensors so that an open circuit simulates an over-hot module,

4. capable (with extra internal equipment) of logging its usage - which may be of use in medical care.

5. It may also remain cold even if "filled" (charged) - until activated.

Fig 8 is a block diagram of this embodiment of the invention, adapted for inductive charging althrough direct connection is also suuitable. 801 is a rechargeable battery (or assembly of batteries). 802 is a control device that in a first mode rectifies coil current (derived from coil 301 when in the charging mode, or meters out battery current to the coil as direct current when in the discharge mode. 802 preferably includes a resonating capacitor and means to detect when the battery has become charged. The metering out process includes a feedback loop comparing the internal temperature as detected by thermal sensor 803 in relation to a predetermined target temperature. If the portable heating device uses resistive wiring buried within in the exterior wall, temperature sensing may be carried out by other wiring buried within in the exterior wall.

Again, the bed warmer is supplied inside a user-friendly covering, and is supplied together with an electrically driven reloading device (as per Fig 7) capable either of reheating one or more modules or of recharging some other batteries which can then be slipped into the module in order to replace discharged batteries. The module (or modules) and reheating device are intended to replace the hot-water bottle as a way of keeping people warm. While a rechargeable battery could start a fire if shorted out when charged, careful design shall minimise that risk. The user-friendly covering, in more detail, shall provide an external perception of softness rather than a hard heavy battery within. Starting at the exterior there is an option of a textile covering (analogous to prior-art hot water bottle covers of wool, cotton or other materials) over a rubber or analogous waterproof, preferably flexible layer. Inside the waterproof flexible layer shall be probably a gel-filled sac containing and protecting the hard material of the electronic assembly. The "gel-filled sac" may be made of a gel which is preferably thermally conductive. Convective heat transfer as with a relatively low-viscosity fluid may be the simplest approach to thermal conductivity. Another approach is to embed heating wires in the waterproof flexible layer, and connect these to the discharge circuit. It will be appreciated that inductive power transfer is an efficient way to reload a battery because the secondary winding behaves as a constant-current source.

It will also be appreciated that a charged battery does not have to be actively discharging straight away. In other words, bed warmers using electronic energy storage as described herein can be in a cold state with respect to temperature even if charged up, and be switched off until needed. A suitable switch to initiate discharge might conveniently be closed by passing the device over a strong magnet. A status indicator such as a LED lamp (off/full/in use) would be useful.

The electronic bed warmer of Fig 8 may also be connected to clothing or footwear that includes warming wires to be substituted for coil 301 when in discharge mode, useful in cold countries or for motorcyclists for electrically heated socks and gloves for example.

INDUSTRIAL APPLICABILITY and ADVANTAGES

Heat energy is conserved - the only item heated is the hot water bottle (bed warmer) itself. Waste of hot water is abolished.

Water is fully conserved because there is no replacement of the water in the bottle (if any) during use of all but one version.

If encapsulated wax or the like is used, the higher Effective Specific Heat provides longer-lasting heat from the bed warmers than if water is used, and the use of latent heat release provides a reasonably constant temperature output until all the material has changed state.

Dangers of conventional hot water bottles (such as scalding with hot water when filling, and over-heating of body parts in contact) are absent. In this case it is of course clear that there is no electricity remaining within the portable heating unit (hot-water bottle analogue) once it has been removed from the rewarming station (apart from versions involving a charged, though low-voltage battery).

A bed-ridden person can replace a cold bed warmer from a bedside re-warming unit as and when required - and there is no need to walk to a cold kitchen to boil a kettle.

All the above advantages are improvements over the standard hot-water bottle, which is simply not allowed in many rest homes and hospitals. Finally, it will be understood that the scope of this invention as described and/or illustrated herein is not limited to the specified embodiments. Those of skill will appreciate that various modifications, additions, known equivalents, and substitutions are possible without departing from the scope and spirit of the invention as set forth in the following claims.

What I claim is:

1. A heating system, capable of replacing the hot-water bottle, characterised in that the heating system includes:
a portable heating unit comprising a sealable flexible container containing a heat-retaining fluid mass, with an electrically powered heating element arranged and adapted to heat the fluid mass in use, the element being connected to a first part of a two-part connector on said container; and a power-supply unit having means for connecting to an electrical power supply in a rewarming station including a second part of said two-part connector complementary to said first part and means to supply electrical power to said heating element when the two parts of said two-part connector are engaged together.

2. A heating system as claimed in claim 1, characterised in that the electrically powered heating element is contained within the container of the portable heating unit, and further includes thermally responsive interruption means capable of deactivating said heating element when the fluid mass in the container exceeds a first given temperature greater than 90 degrees Celsius.

3. A heating system as claimed in claim 1, characterised in that said rewarming station includes a heat sensor arranged to detect a temperature of said portable heating unit when the two parts of the two-part connector are engaged together, and a switch by which said means to supply electrical power to said heating element can be deactivated, said switch being operable when a temperature detected by said heat sensor exceeds a second, selected temperature.

4. A heating system as claimed in claim 3, characterised in that said heat sensor includes means for interpreting infrared radiation received from said portable heating unit as a temperature.

5. A heating system as claimed in claim 1, characterised in that said rewarming station includes at least one chamber each shaped and dimensioned to receive and hold one portable heating unit, each two-part connector comprises a socket and complementary peg each including electrical contact means, the socket being provided at an end of said portable heating unit and the peg being provided as a projection inside said chamber of the rewarming station, so that power from within the rewarming station can pass through the

electrically powered heating element inside the personal heating unit.

6. A heating system as claimed in claim 5, characterised in that said rewarming station includes sensor means to detect the presence of the portable heating unit in said chamber, and includes means to permit the supply power to said heating element only when the portable heating unit is detected in said chamber.

7. A heating system as claimed in claim 1, characterised in that the heat-retaining fluid mass in the portable heating unit is comprised at least in part of water.

8. A heating system as claimed in claim 7, characterised in that said heat-retaining fluid mass in said portable heating unit comprises a mixture of particulate solid items and water.

9. A heating system as claimed in claim 8, characterised in that each particle of said particulate solids is comprised of an encapsulated substance having a melting point between 45°C and 95°C.

10. A heating system, characterised in that the heating system includes: a power-supply unit having means for connecting to an electrical power supply and means for creating electrical energy transmissible without wires and coupling said energy into a connector-less portable heating unit; the portable heating unit comprising a sealable flexible container containing a heat-retaining fluid mass; the mass including energy-capturing means capable of capturing oscillating electrical energy received from the power-supply unit and of converting said energy into heat within said fluid mass.

11. A heating system as claimed in claim 10, characterised in that the heating element comprises a resistive wire coil in said container, and the means to supply electrical power to said heating element comprises an induction coil in said power supply unit, positioned and arranged to induce a current in said resistive coil when the two parts of said two-part connector are in proximity.

12. A heating system as claimed in claim 10, characterised in that the energy-capturing means comprises water, and the means to supply electrical energy to said energy-capturing means comprises a generator of electromagnetic energy having a frequency such that the energy is capable of effective absorbtion by water, positioned and arranged to cause the water to become heated when the generator is in use.

13. A heating system as claimed in claim 10 or in claim 12, characterised in that the heating system includes sensor means for sensing the temperature of the portable heating unit; the sensor means being operatively connected to cutoff means capable of limiting the supply of energy to said portable heating unit so that said portable heating unit cannot be heated beyond a predetermined temperature.

14. A heating system as claimed in claim 10 or claim 12, characterised in that said power supply unit includes sensor means to detect a presence of the portable heating unit in said chamber, and includes means to permit the supply power to said heating element only when the portable heating unit is in place within said chamber.

15. A heating system, characterised in that the heating system includes: a rewarming unit having means for connecting to an electrical power supply and means for transferring electrical energy into storage within a rechargeable battery contained within a portable heating unit; the portable heating unit comprising a sealable flexible container containing activatable means for converting the energy within the battery into heat to be released from the portable heating unit in a temperature-regulated manner.

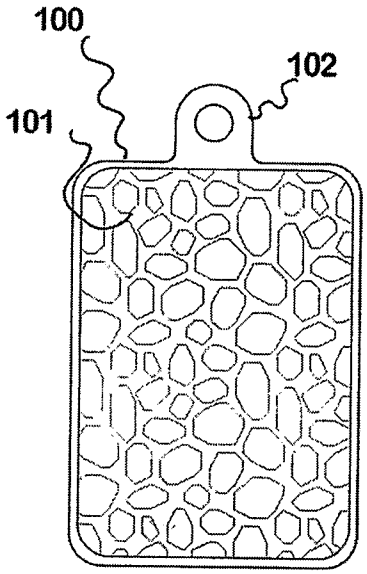


Fig 1

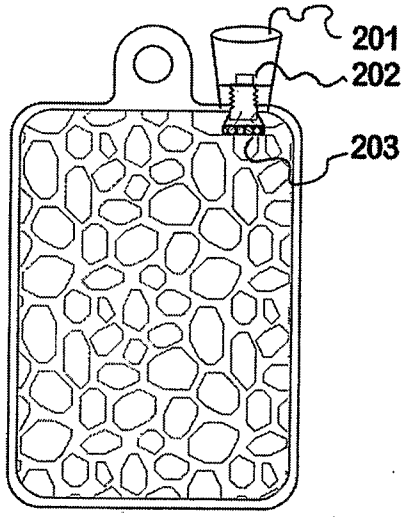


Fig 2

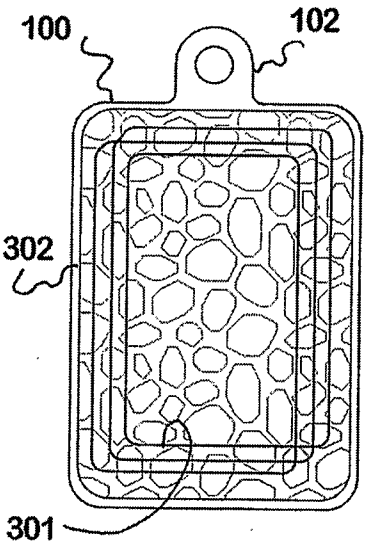


Fig 3

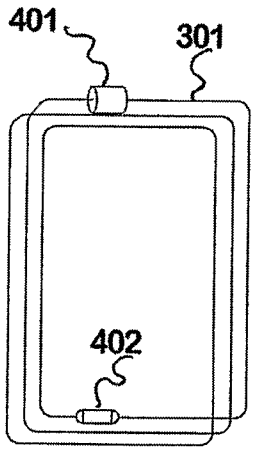


Fig 4

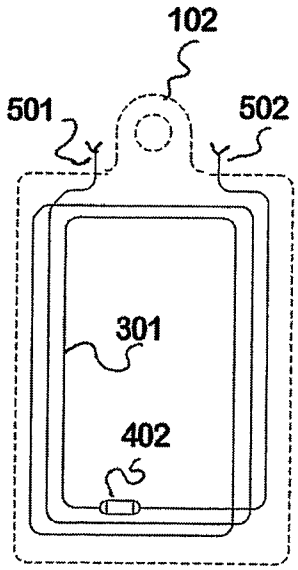
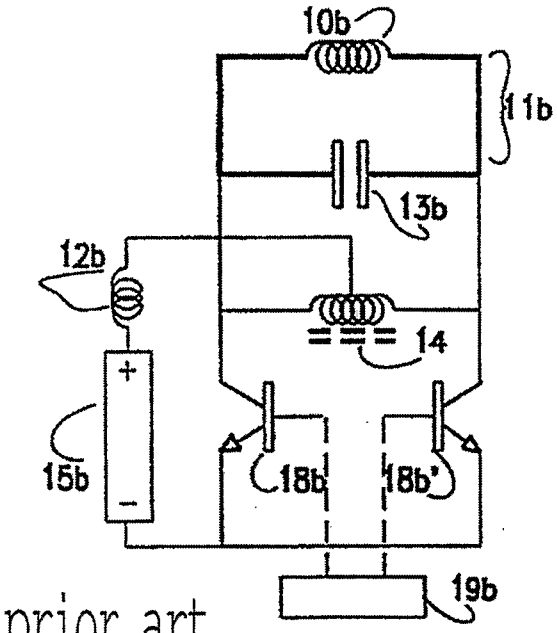


Fig 5



prior art

Fig 6

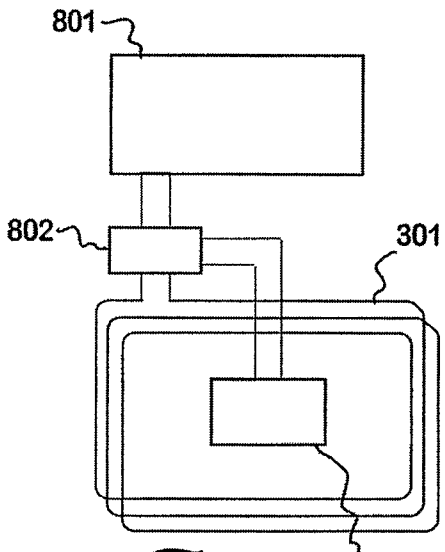


Fig 8

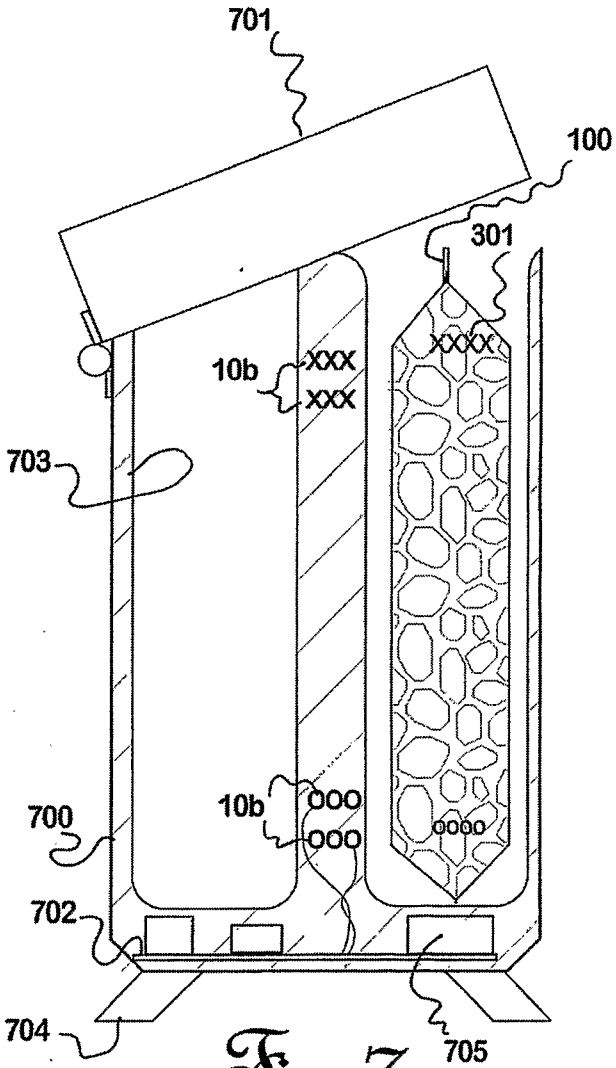


Fig 7

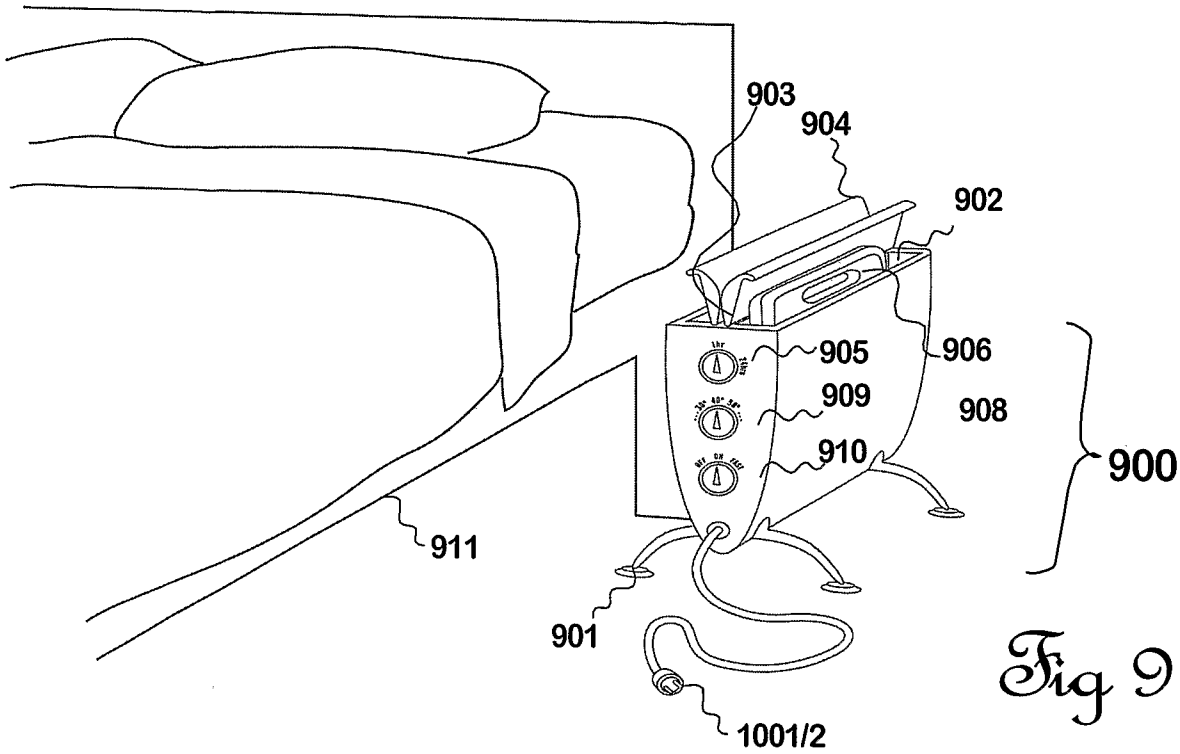

903
904
902
905
906
909
908
910
900
911
901
1001/2

Fig 9

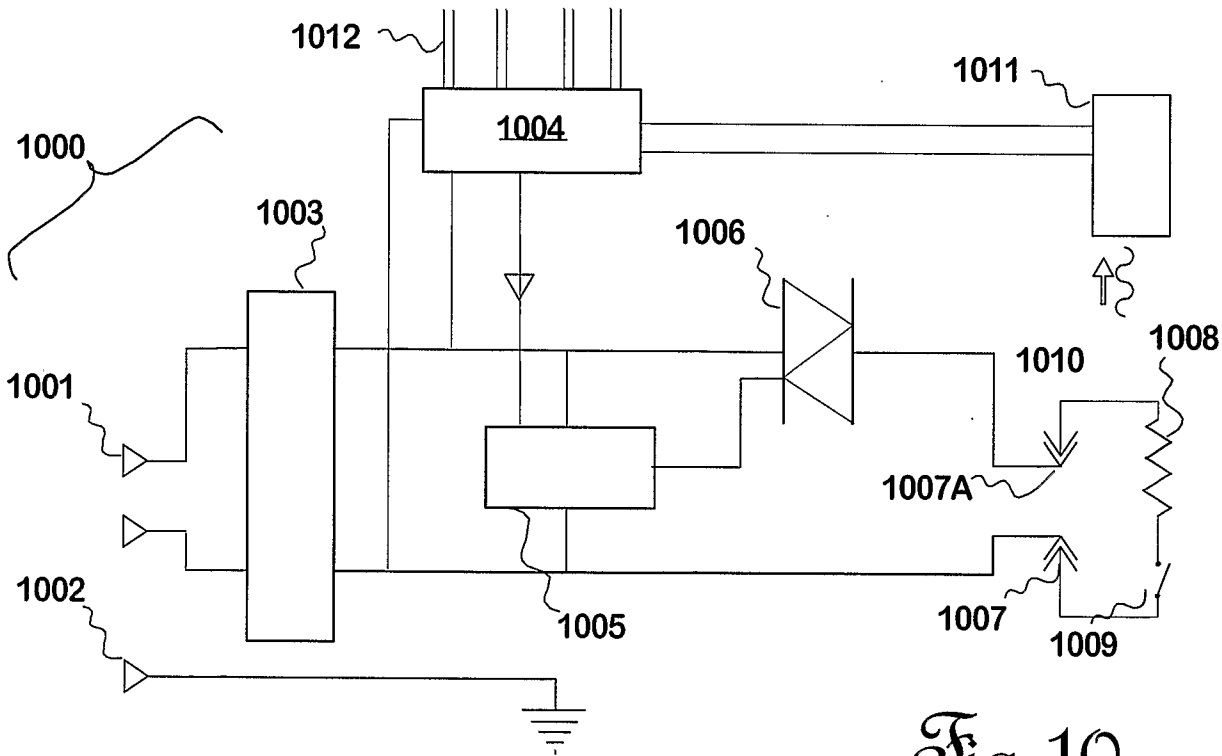
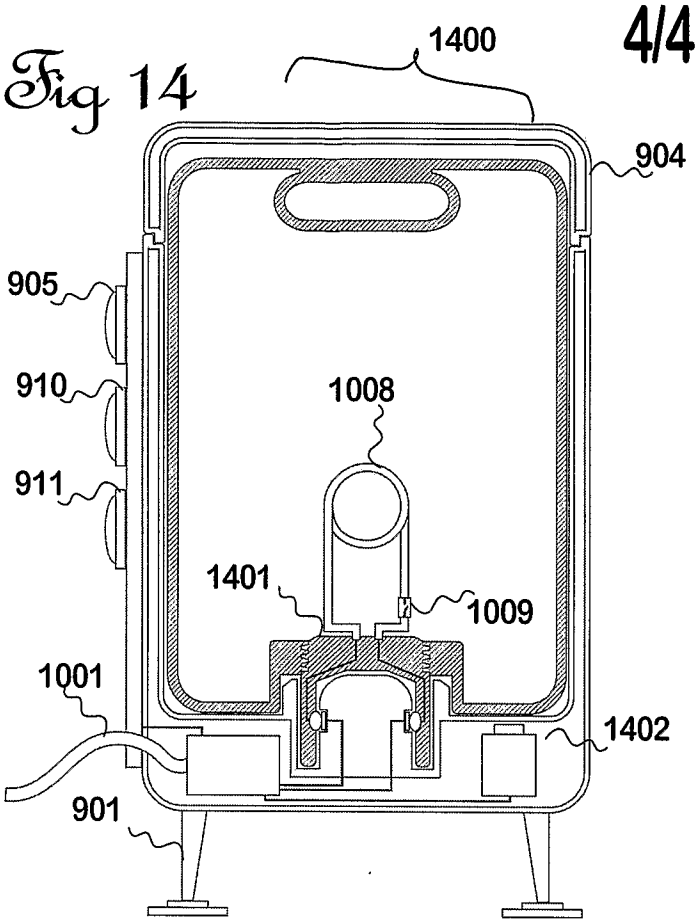

1012
1011
1004
1000
1003
1006
1001
1010
1008
1007A
1002
1005
1007
1009

Fig 10

Fig 14



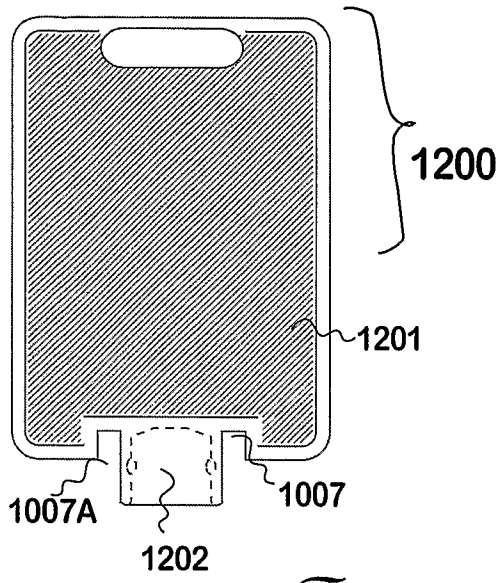
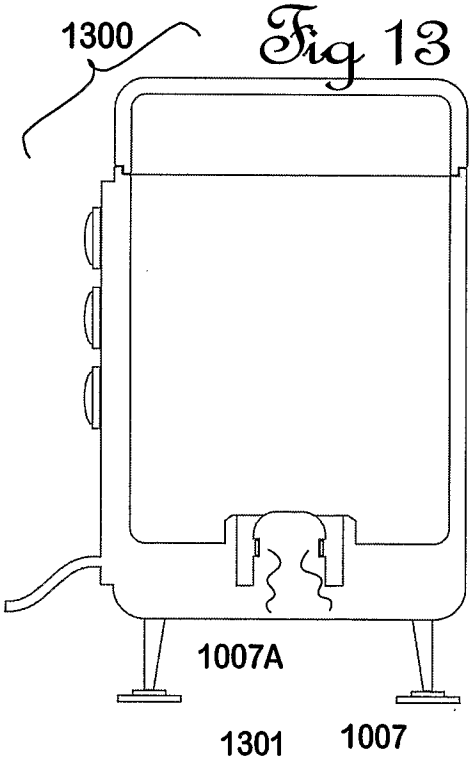


Fig 12

Fig 13



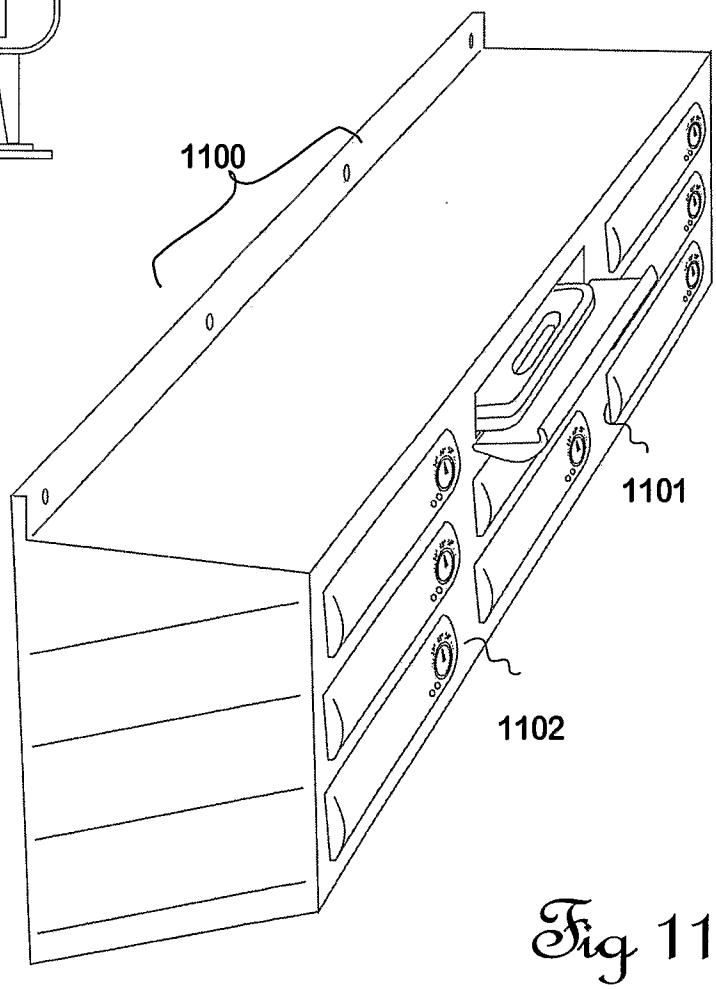


Fig 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2007/000075

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. ***A61F 7/08*** (2006.01) ***A47C 21/04*** (2006.01) ***H05B 3/00*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: IPC A61F 7/-, A47C 21/04, H05B 3/- & Keywords (Portable, Thermal, Warm, Container, Bag, Bottle, Reuse, Rewarm, Flexible, Sealed, Electric, Element, Loop, Induction, Hot Water Bottle) and similar terms; Esp@ce: A61F & Keywords (Electric, Bottle, Microwave, Heat, Pack)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2192118 A (PETER MAPPLEBECK & ASSOCIATES ESTS) 31 December 1987 See whole document. Figures 1 and 2 especially.	1-14
X	GB 2402346 A (HOWELL) 12 August 2004 See whole document. Figures 1 and 2 especially.	1-14
X	GB 2370993 A (PARK) 17 July 2002 See whole document.	1-14

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 July 2007	23 JUL 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **ROGER SMALL** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 7998

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2007/000075

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1 to 14

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2007/000075

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/021117 A1 (E.CO ENGINEERING & CONSULTENCY B.V) 29 March 2001 See whole document.	1-14
X	GB 2110060 A (AQUATRON (SHOWERS) LIMITED) 8 June 1983 See whole document.	1-14
X	GB 296030 A (ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT) 22 November 1929 See figures 1 to 3.	1-14
X	GB 2135860 A (MATOSSIAN et al.) 5 September 1984 See whole document.	1-14
X	US 6416534 B1 (MONAGNINO et al.) 9 July 2002 See figure 3A.	1-14
X	Derwent Abstract Accession No. 99-133907/12, Class P32, DE 29820516 U1 (TRAPP) 11 February 1999 See abstract and drawing.	1-14
X	US 6141801 A (HELENICK) 7 November 2000 See abstract and figures.	10, 12
X	GB 2323033 A (WANG) 16 September 1998 See whole document.	10, 12
A	JP 2001-276109 A (HASHIMOTO) 9 October 2001 See figures 1 and 2.	
A	GB 2291321 A (CHAINPORT LIMITED) 17 January 1996 See figures 1 and 2.	
A	US 6348678 B1 (LOYD, SR. et al.) 19 February 2002 See figures 1 to 4.	
A	WO 1998/017213 A1 (THERMAL ENERGY ACCUMULATOR PRODUCTS PTY LTD) 30 April 1998 See whole document.	

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-9 relate to a portable heating unit containing a heat-retaining fluid mass with an electrically powered heating element adapted to heat the fluid mass when the element is connected to a power-supply unit having connection means to an electrical power supply when two parts of a ***two-part connector*** are engaged together.

- Claims 10-14 relate to a heating system including a power-supply unit connectable to an electrical power supply and having means for creating electrical energy transmissible ***without wires*** and a ***connector-less*** portable heating unit containing a heat-retaining fluid mass and including energy-capturing means capable of capturing oscillating electrical energy received from the power-supply unit and converting the energy into heat with the fluid mass.

- Claim 15 is related to a heating system including a rewarming unit having connection means to an electrical power-supply which thereby allows for the ***transfer of electrical energy into storage within a rechargeable battery*** contained within a portable heating unit containing activatable means for converting the energy within the battery into heat to be released from the portable heating unit.

Since these groups of claims do not share any of the special technical features identified, a technical relationship between the inventions does not exist. Accordingly the claims do not relate to one invention or to a single inventive concept, a priori.

The International Searching Authority believes that a search and examination for the second invention (claims 10-14) will not involve more than negligible additional search and examination effort over that for the first invention (claims 1-9). Since both these inventions relate to means of heating a portable unit containing a heat-retaining fluid mass it is considered that they can be searched together, however it is considered that the search for the third invention (claim 15), will require significant additional search and examination over that for the first invention.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/NZ2007/000075

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
GB	2192118				
GB	2402346				
GB	2370993				
WO	2001021117	AU	58848/99		
GB	2110060				
GB	296030				
GB	2135860				
US	6416534				
DE	29820516				
US	6141801	AU	31893/99	WO	1999047011
GB	2323033	US	5645749		
JP	2001276109				
GB	2291321				
US	6348678	US	6486452	US	2002047007
WO	1998017213	AU	45453/97		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX