US 20130037019A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2013/0037019 A1

Bruwer et al. (43) Pub. Date: Feb. 14, 2013

(54) WATER HEATER WITH INTERMITTENT ENERGY SOURCE

(76) Inventors: **Frederick Johannes Bruwer**, Paarl (ZA); **Frederick Johannes Bruwer, JR.**, Paarl (ZA)

(21) Appl. No.: **13/642,614**

(22) PCT Filed: **Apr. 21, 2011**

(86) PCT No.: **PCT/ZA11/00026**

§ 371 (c)(1), (2), (4) Date: **Oct. 22, 2012**

(30) **Foreign Application Priority Data**

Apr. 21, 2010 (ZA) 2010/02827

Jul. 19, 2010 (ZA) 2010/05107

Publication Classification

(51) **Int. Cl.**

F24H 9/20 (2006.01)

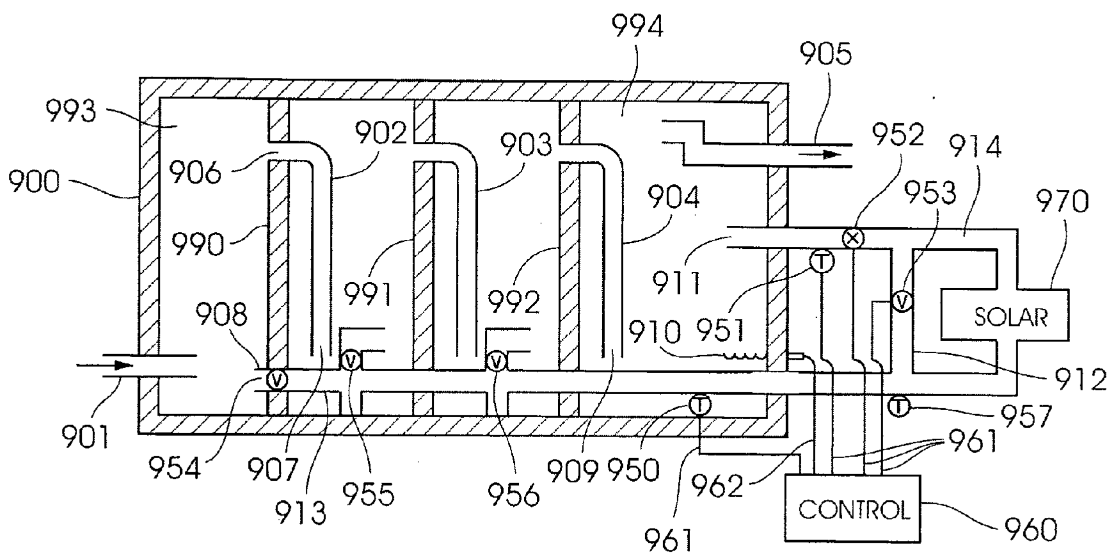
F24J 2/42 (2006.01)

F24H 1/10 (2006.01)

(52) **U.S. Cl.** **126/615**; 122/19.1; 122/14.1

(57) **ABSTRACT**

A water heater with a hot water compartment, the volume of which is decreased when hot water is discharged. The remaining hot water is prevented from mixing with replacement cold water. The volume of the compartment is increased again when cold water has been heated and is pushed into the hot water compartment. The water heater is divided into a receiving compartment for water at ambient temperature and a compartment from which heated water is discharged for normal usage. The previously heated water is thereby prevented from mixing with replacement cold water. All compartments can be heated or the compartments can be heated individually. The water heater keeps the hot water temperature high between usage activities, and is suited for an intermittent energy source, e.g. solar power.



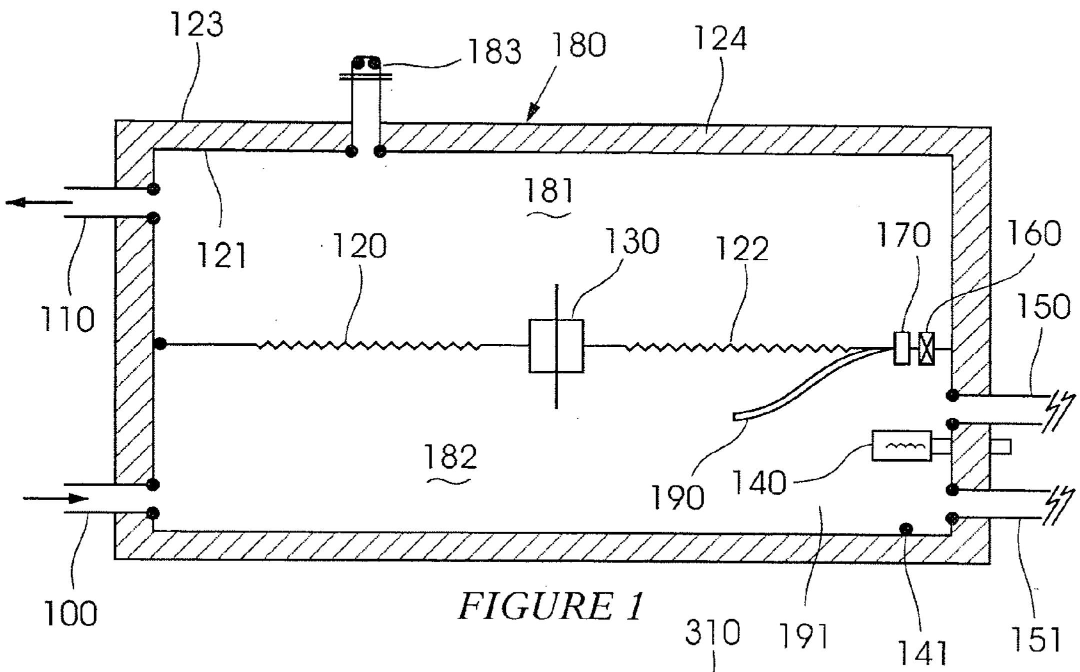


FIGURE 1

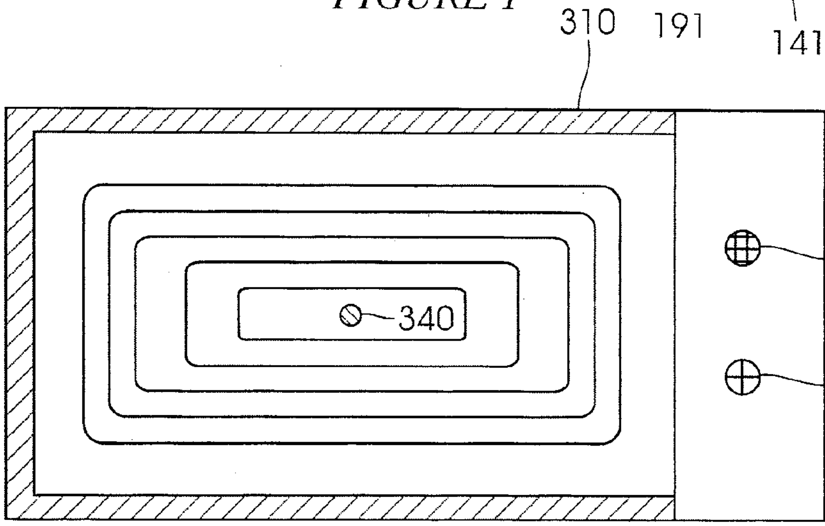


FIGURE 2

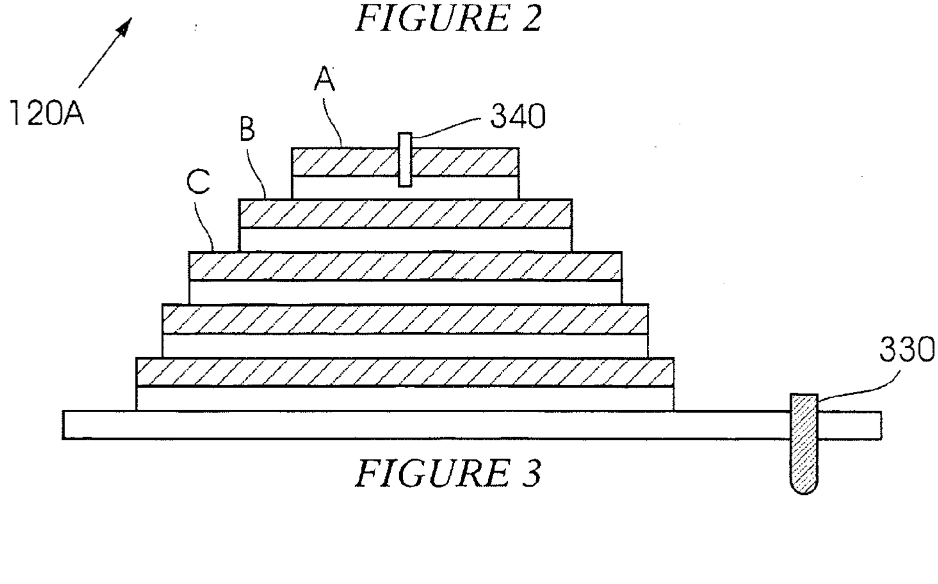


FIGURE 3

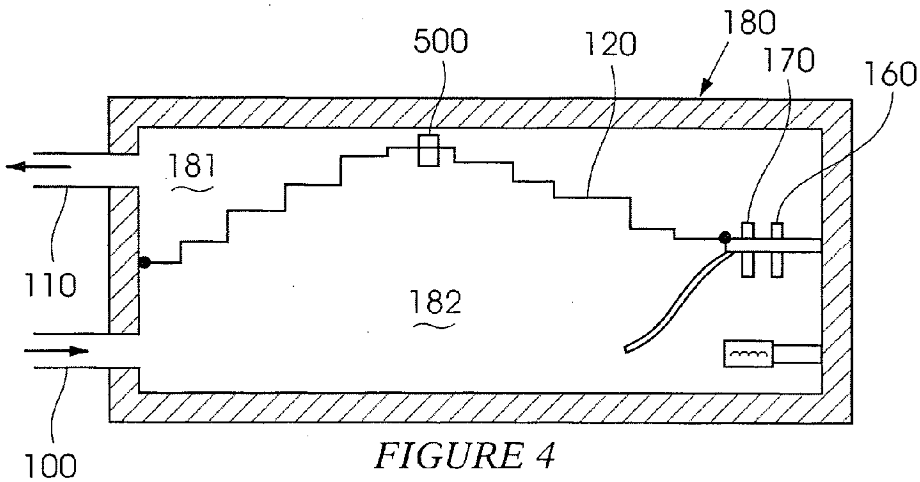


FIGURE 4

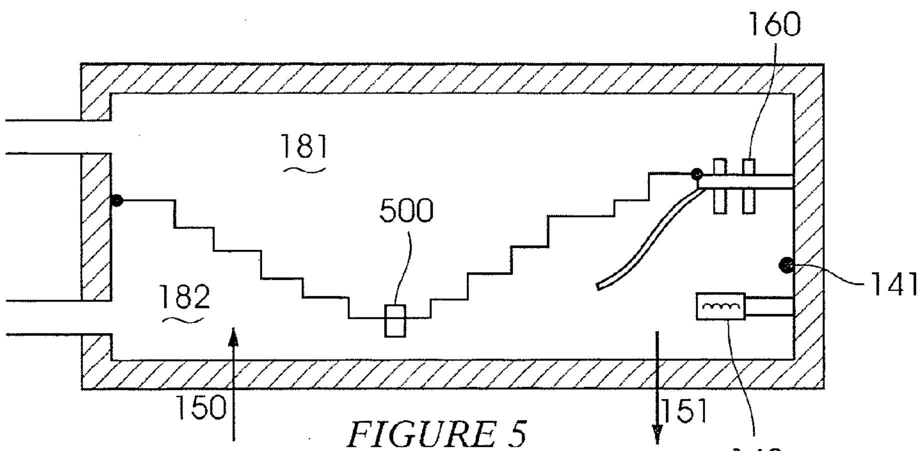


FIGURE 5

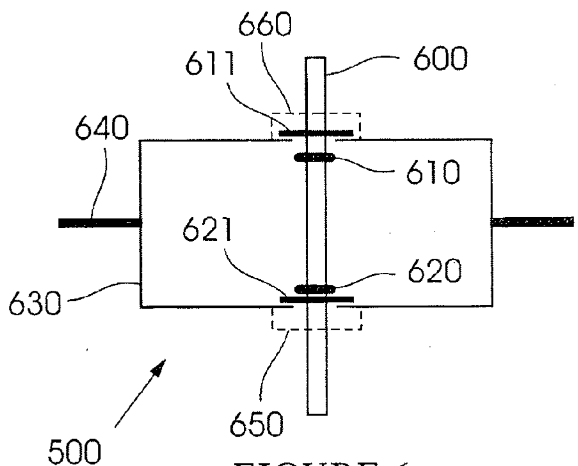


FIGURE 6a

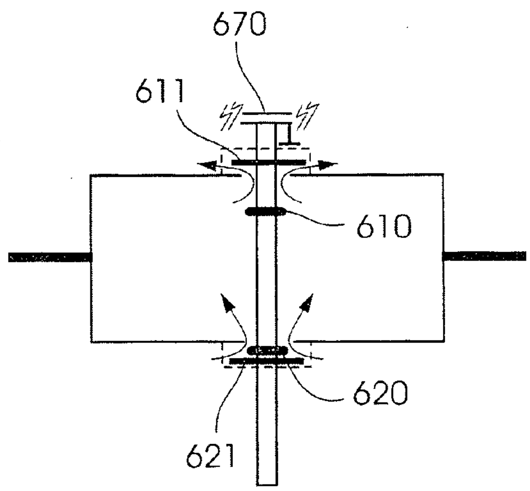


FIGURE 6b

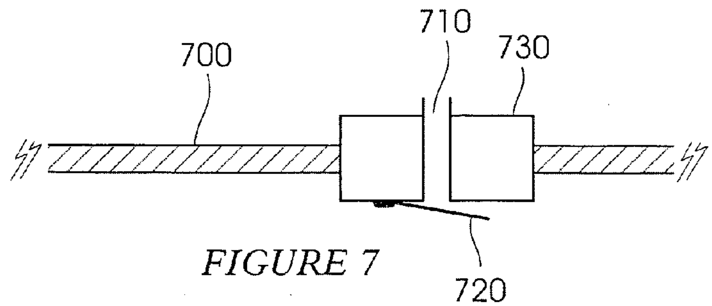


FIGURE 7

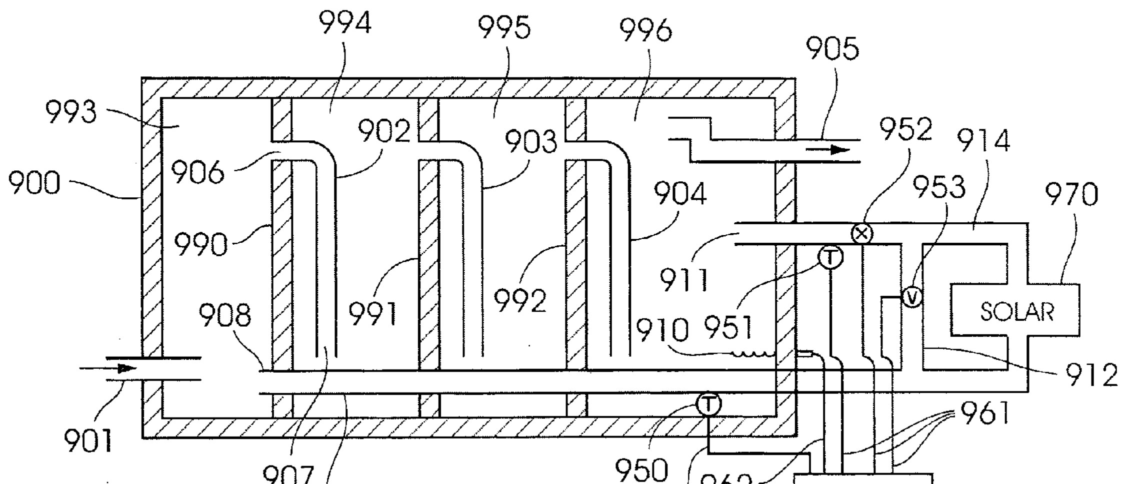


FIGURE 8a

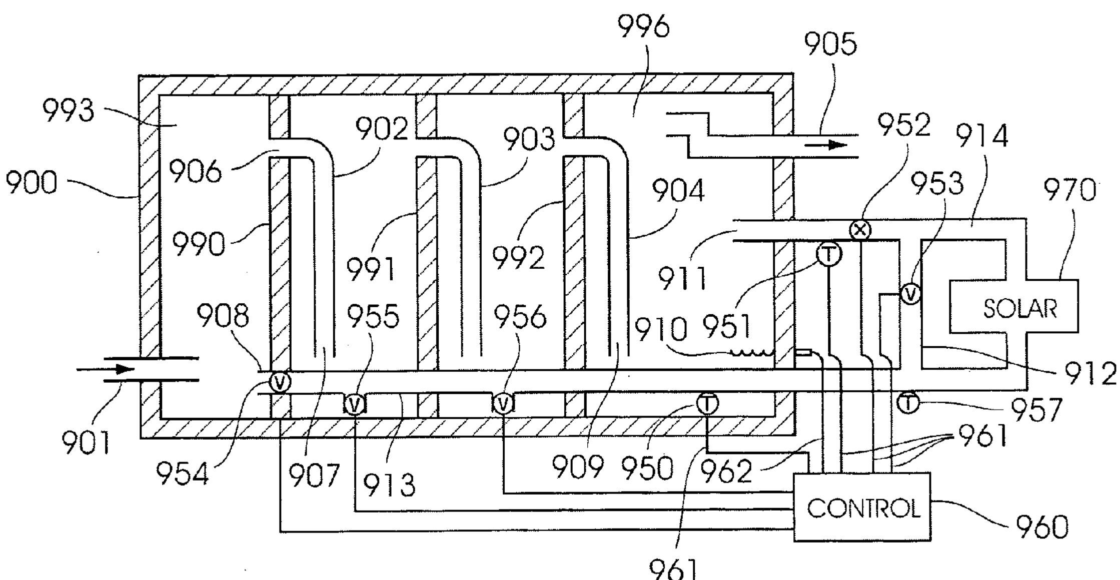


FIGURE 8b

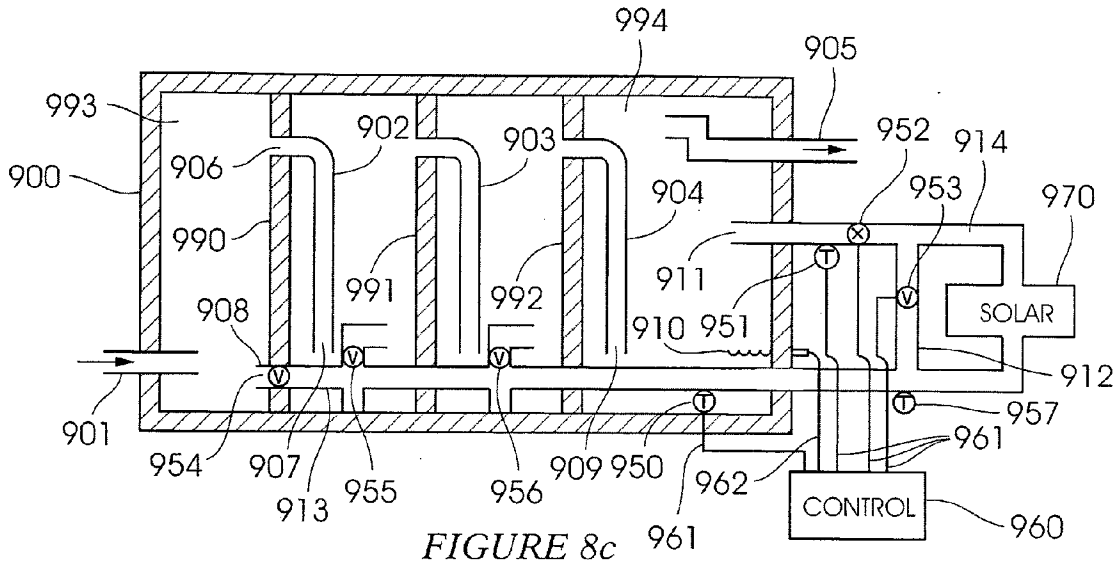


FIGURE 8c

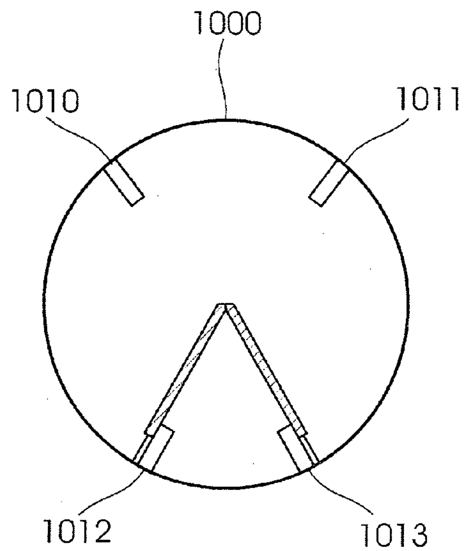


FIGURE 9a

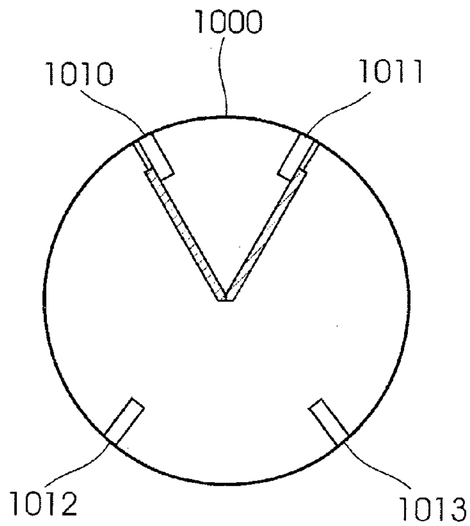


FIGURE 9b

WATER HEATER WITH INTERMITTENT ENERGY SOURCE

BACKGROUND OF THE INVENTION

[0001] This invention relates to water heating systems.

[0002] Energy conservation has become a growing priority. As water heating uses a large amount of energy it is logical that solar and other energy-efficient water heating systems have grown in popularity.

[0003] However, many of these heat sources are intermittent, i.e. solar heating is only effective while the sun is out. Some residences choose to switch off their water heaters when not in use. In areas that have different power tariffs for different times of the day, people may choose to install timer switches that switch on only when economical. Load shedding in some countries allows an electricity supplier to switch off a water heating system unbeknownst to a household.

[0004] Well-insulated water heaters can store water preheated by these systems overnight, but when heated water is drained it is immediately replaced by cold water which mixes with and cools the remaining stored hot water. The preheated water is rendered unusable until the preferred heating source is available again or it has to be reheated by an alternative source requiring more energy or more expensive energy.

[0005] Prior patents dealing with these issues include U.S. Pat. No. 4,598,694 and U.S. Pat. No. 7,570,877. In U.S. Pat. No. 4,598,694 cone-shaped inserts are placed in a vertically mounted water heater to stratify water in a predetermined pattern, keeping warm water away from sides at which most heat loss takes place. This device does not, however, separate cold inlet water from preheated water within a storage chamber. In U.S. Pat. No. 7,570,877 a separation board creates a large and a smaller compartment that are used for heat storage space and instantaneous heating space respectively. This device has the disadvantage of requiring a permanent heat source within the instantaneous heating compartment and can therefore not be used effectively with intermittent heat sources.

[0006] Another prior art system (U.S. Pat. No. 5,898,818—April 1999) makes use of a bag-like container and various mechanisms to maintain a force (springs, motors) to immediately, after usage, push cold water from the bag into a hot water compartment where it is then heated. The objective seems to be that a small single cylinder for storing hot water is used and during a single usage action the hot and cold water are prevented from mixing. Immediately afterwards hot and cold water are mixed. The cold water per the design enters the system above the hot water, which does not allow use of water stratification effects due to a temperature difference that would allow hot water flow upward between compartments.

[0007] Another patent—U.S. Pat. No. 4,692,592 also discloses techniques to achieve improved water heater energy source usage.

[0008] It is an object of this invention to provide an economically viable improvement to a standard water heating system that can overcome the energy efficiency shortcomings discussed above. As water heating is responsible for a notable percentage of an average residence's energy consumption and carbon footprint, this holds definite market value.

SUMMARY OF THE INVENTION

[0009] This invention presents methods and means to improve and overcome problems related to water heating systems (e.g. household water heaters or geysers) to keep hot water temperature constant at a high value, especially in a system that has an intermittent energy source or, at least, a preferred, intermittent energy source.

[0010] Examples are a solar energy water heater, an electric or gas water heater on a timer, and a water heater in an area affected by load shedding or load balancing.

[0011] In one form, the invention provides a water heater with a variable size hot water compartment or section. It is also possible that the full capacity of the water heater may be constant, but the water heater is split into two or more compartments with a divider, e.g. a temperature insulating partition, such as a membrane, between them in order to generally prevent cold water which flows into the water heater from freely mixing with previously heated water, i.e. the hot water inside the heater.

[0012] The objective is simple—when the energy source is absent (e.g. at night for a solar water heater) the hot water compartment is shrunk when hot water is extracted from the water heater rather than, as is the state of the art now, allowing the extracted water to be replaced with cold water flowing in from a main supply and mixing in the same compartment with the remaining hot water.

[0013] The volume of the hot compartment may be reduced until a minimum size is reached. If this minimum size is reached, cold water will start to flow into the hot water compartment or to an outlet. At this stage another energy source must be engaged for water heating, otherwise the user will no longer be supplied with hot water.

[0014] The water compartment of the water heater is thus preferably split into sections, e.g. two sections, namely a so-called heated water compartment and an ambient water receiving compartment. These two sections are separated, e.g. by a membrane or separation element which, preferably has insulating properties. The separation element may be flexible or movable or in some way able to vary the sizes of the compartments. Several examples of individual actions or operations can be identified for a practical implementation:

[0015] (a) When hot water is extracted from a water heater in a sealed system, the hot water flowing out is replenished by cold water flowing in. The cold water flowing in can freely mix and hence lower the average temperature of the remaining water in the water heater. This is normally acceptable when the energy source is active and immediately starts to heat the water to regain the set temperature of the water heater.

In an embodiment of this invention the cold water flowing into the water heater from the main supply is kept in a receiving compartment and is separated from previously heated water in a hot compartment, preferably by a temperature insulating element/layer/membrane. This means that the hot compartment must shrink and the receiving compartment must expand in order to maintain equilibrium of a sealed system.

[0016] (b) Water is transferred (under normal operation where the hot water was not depleted as in when the hot compartment reached a minimum size due to usage of hot water) from the receiving compartment to the hot compartment when some water in the receiving compartment has reached a predefined temperature. This operation will cause the hot compartment to expand and the receiving compartment to shrink.

[0017] (c) When the hot compartment has reached a minimum capacity, and more water is extracted from the water heater, cold water will flow directly from the receiving compartment into the hot compartment or directly to a hot water outlet through a pressure release valve. This water may possibly now not be at the required temperature set for the water heater.

[0018] (d) When the hot water compartment is at maximum capacity (i.e. the receiving compartment is at minimum capacity) and water is still heated to a point at which it flows into the hot water compartment from the receiving compartment, a mechanism must exist to allow flow from the hot compartment into the receiving compartment. Preferably the design must be such that in this operation the coldest water from the hot compartment is automatically transferred to the receiving compartment.

[0019] (e) The temperature of the water flowing from the hot water compartment to the receiving compartment may be monitored and the heating of water may be terminated when a preset maximum temperature is reached.

[0020] The separation element may be of a stretchable nature or may be designed with a concertina, accordion or "show and hide" structure to expand towards the hot or receiving compartment.

[0021] In another embodiment the total capacity of the water heater may vary, i.e. an aspect of the invention allows for the hot compartment to shrink when hot water flows from the water heater. In this case the hot compartment will expand when cold (new) water is heated to a level at which it is transferred into the hot compartment. The receiving compartment may be non-existent or of a very small fixed size or merely comprise a flow volume around a heating element.

[0022] Flow between the various compartments may result due to water stratification principles e.g. hot water rising and cold water falling in a mix; or electromechanical force e.g. using an electric motor to pump the water; or gravitational pull or system pressure; or in fact a mix of forces may play a role in the full design. Valves used to control water flow may be of a spring or bimetal type, or may be actuated electronically or may be wax pellet, thermostat type valves as found in vehicle radiators. Temperature may also be measured using thermometers of various kinds and the output may be supplied to valves or electronic circuits to interpret the data and to provide information on parameters such as gradient of heating and instant temperature at a point or multiple points in the system.

[0023] The material forming an insulating layer may typically be chosen to be buoyant neutral, but the design may in fact require it to be slightly positively buoyant or in many cases denser than water. It is preferable that the material should last for the lifetime of the water heater in the hot/cold environment and should not affect the quality of the water, nor should it at any time release poisonous or toxic substances into the water.

[0024] In many cases a denser than water layer is advantageous because it will naturally want to enlarge the lower compartment and this will assist in enlarging the top compartment volume under the correct conditions.

[0025] In another embodiment the internal cavity of the water heater is divided into multiple compartments, each with fixed total and individual volumes. Of these compartments: one is a receiving compartment for water at ambient temperature: one or several are transition compartments; and one is used as a "hot" compartment from which heated water is discharged for normal usage. Water flow between compartments is made possible by (links) ducts running from the top of one compartment to the bottom of a neighbouring one. Under normal standby circumstances water stratification will take place in each compartment. Therefore, when hot water is discharged during normal use, the hottest water from one compartment will flow into the next one and the hottest water will propagate to the "hot" compartment. This mechanism prevents cold water flowing into the water heater receiving compartment from mixing with all the hot water and therefore, over time, lowering the temperature of the hot water.

[0026] The water in the compartments is heated by circulating colder water from the receiving compartment through the heating source, (e.g. LPG, electrical heating element, solar heater, cyclotron etc.) which can be located internally or externally, and depositing the heated water in the "hot" compartment. The circulation may result due to water stratification principles i.e. hot water rising and cold water falling in a mix, electromechanical force i.e. using an electric motor to pump the water, gravitational pull or system pressure or in fact a combination of forces may play a role in the full design. The heated water entering the "hot" compartment displaces the colder water at the bottom of the compartment and forces it backwards into a neighbouring transitional compartment. This works in the opposite direction as when discharging hot water from the water heater for normal use. It is also taking water from the bottom of the hot compartment and pushing it into the top of the following compartment. This process continues until the whole system is at a predefined temperature at which point heating could either be halted or slowed down to maintain that temperature.

[0027] The heat source could also be located in the "hot" compartment thereby enabling the user to heat only that compartment; this is especially beneficial for providing a small amount of hot water for e.g. shaving or dishwashing when the preferred energy source is not available.

[0028] In a case where there is an intermittent preferred heat source (e.g. solar heating), the source could form part of the heating loop with a bypass valve that opens when the specified source is not available. The valve could be an electronic thermostat type valve that opens if the temperature of the water leaving the preferred heating source is too low. If an electric pump is used for circulation its speed can be regulated according to the temperature of the water to be heated so the water entering the hot compartment can be heated to a predefined temperature.

[0029] The separation layers that form the compartments should preferably have insulating properties. The water heater as described in this invention is ideal to operate with only solar power or where the solar power is augmented with another energy source (i.e. LPG or electricity). By using the key features of the invention the use of the secondary power source can be kept to a minimum.

[0030] A good example is where household hot water usage is typically at night and in the morning, but in a solar power system the energy source is not available at night. If hot water is used at night the cold water replacing it in the water heater causes the rest of the previously heated water to become much colder. Typically the water heater is then used with a time switch that allows the water to be heated before it is required in the morning. However, this is also directly before the free energy source becomes available.

[0031] Using this invention the electricity need not be activated in the morning and will only become necessary during rainy periods when the solar power cannot keep up or when usage is too high.

[0032] Although the summary generally describes the use of a horizontally positioned water heater the invention also applies to a vertically positioned water heater, possibly requiring slight modifications for example where an AC or LPG heating element is situated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The invention is further described by way of examples with reference to the accompanying drawings in which:

[0034] FIG. **1**—an example of a water heater with variable compartments;

[0035] FIG. **2**—an example of an insulating member construction (top view);

[0036] FIG. **3**—an example of the insulating member construction (side view);

[0037] FIG. **4**—a hot compartment at minimum size;

[0038] FIG. **5**—the hot compartment at maximum size;

[0039] FIG. **6**—an example of a dual unidirectional valve that becomes operational at minimum and maximum volumes;

[0040] FIG. **7**—a simplified valve for unidirectional circulations;

[0041] FIG. **8***a*—a water heater, with multiple fixed compartments, that is suitable for dual energy source operation.

[0042] FIG. **8***b*—the water heater of FIG. **8**(*a*) with modifications to allow heating of individual compartments;

[0043] FIG. **8***c*—special separation of a compartment to provide improved insulation against heat loss; and

[0044] FIGS. **9***a* and **9***b* which respectively show another implementation of variable capacity compartments full of hot water and with minimum hot water.

DETAILED DESCRIPTION OF THE INVENTION

[0045] In FIG. **1** a water heating unit is diagrammatically displayed in a cut through side view. A wall or casing of the unit is shown as **180**. Typically there is an inner wall **121** containing the water and an outer wall **123** with thermo-insulating material **124** in between to reduce heat radiation from the heated water and, thus, energy wastage. This is similar to what is used in the art.

[0046] A cold water inlet (**100**) is at the bottom left with a hot water outlet (**110**) at the top left. The volume of water contained in the water heater is split into a hot compartment (**181**) and a receiving (cold) compartment (**182**) by a thermo-insulating membrane or layered structure (**120**). One side of the structure is attached to the wall (**121**), whereas the other side (**122**) is attached to a cover plate/conduit structure (**190**) that may also serve to support a thermostat (**160**) and a pressure transfer valve (**170**). The unit also contains other standard elements of a water heater such as a pressure release valve (**183**) and heating element (**140**).Other standard elements are not shown but can readily be found in the art (e.g. temperature adjustment mechanism, mounting brackets etc.) and a mechanism for preventing the heating element from being damaged when no water is present.

[0047] The thermostat (**160**) may be of a wax pellet, bimetal or other type, that will open in order to allow rising hot water to flow into the hot compartment **181** from the receiving compartment **182** when the temperature of the water in the section of the receiving compartment area generally defined by member (**190**) is above the opening point of the wax pellet thermostat (**160**). Other types of valves may be used. For example the temperature may be sensed electronically and a solenoid type valve may be opened at the defined temperature with the water flowing due to stratification or a propeller mounted on a electric motor (pump action). If the water is not hot enough to cause the thermostat to open, it will circulate in the enclosure generally defined by wall (**180**) and member (**190**) and gradually build up temperature until a predetermined thermostat opening temperature is reached. If the heating element cannot maintain a constant flow of heated water, the thermostat will close again when surrounded by colder water and the cycle will repeat itself.

[0048] The pressure transfer valve (**170**) is a boundary element and opens when the pressure difference between the receiving compartment (high pressure) (**182**) and the hot compartment (low pressure) (**181**) becomes higher than a predefined value. This happens, for example, when the receiving compartment reaches its maximum volume (see FIG. **4**) and cannot expand any more to compensate for water flowing in and water flowing out of the water heater. The receiving compartment is basically at the standard mains water system pressure but, due to the outflow and the fact that the hot compartment is now fixed at the minimum volume, the pressure in the hot compartment will decrease. If the differential is high enough, water will flow through the pressure transfer valve (**170**) irrespective of the water temperature. This also happens when the water heater is installed and filled with water for the first time.

[0049] The separation layer (**120**) is preferably denser than the water i.e. it has negative buoyancy and thus has a tendency to want to enlarge the hot compartment and shrink the receiving compartment. Unless the thermostat (**170**) opens, this cannot happen due to the balanced pressure between the two compartments. However, should the water be heated by an energy source above the specified temperature and the thermostat opens, water can flow from the receiving compartment into the hot compartment through the thermostat valve. Now the hot compartment will increase in size to accommodate the hot water flowing from the receiving compartment into the hot compartment, and the receiving compartment will shrink by an equivalent volume. The negative buoyancy of the insulating member may also arise from including a circulating valve (**130**) structure in the member.

[0050] Assume the water heater is in an equilibrium position with enough hot water (i.e. hot compartment not at minimum volume) for supply purposes, and the thermostat (**170**) is closed, i.e. no hot water is to flow from the receiving compartment to the hot compartment. When the user opens a hot water tap (faucet) and water flows from the outlet (**110**), the pressure in the hot compartment drops and is immediately compensated for by the separation member moving to make the hot compartment volume smaller and the receiving compartment volume larger. The lower pressure in the receiving compartment is compensated for by water flowing in from the system mains supply and when the user closes the tap (faucet) the system pressure is balanced again. Essentially the hot compartment size is reduced by the same volume as the water that flowed through the tap. The cold water flowing into the receiving compartment has the same volume and is separated from the hot water in the hot compartment by the member (**120**), which preferably has thermal insulating properties.

[0051] This will help to keep the previously heated water from mixing with the cold water and thus lowering the average temperature of the previously heated water. When the energy source for heating the water is available the water in the hot water compartment must be replenished through heating water in the receiving compartment until it reaches the transfer temperature into the hot compartment through the thermostat. This action will allow for the hot section to become larger in volume and the receiving section to become smaller.

[0052] When the hot compartment has reached its minimum size (i.e. receiving compartment is at maximum) further outflow will be compensated for by water flowing through the pressure transfer valve (**170**) or in some embodiments by a min/max valve as shown in FIG. **6**.

[0053] FIG. **2** is a top view, and FIG. **3** a side view of a specific embodiment of the separation/insulation member or layer **120**A. This is an example only of a practical implementation and many other solutions are possible, such as stretching material or sliding at an attaching point. This example is not to be understood as limiting the scope of the invention. The layer **120**A is of a concertina/accordion structure with multiple interconnected components A, B, C . . . allowing it to stretch in either direction in a structured manner. The layer includes a mounting frame **310** which carries a pressure valve **320** and a thermostat **330**. A circulation valve **340** is vertically positioned in the component A.

[0054] FIG. **4** shows the hot and receiving compartments at minimum and maximum size respectively, and vice versa in FIG. **5**. A min/max valve (**500**) is used to allow flow from the receiving to the hot compartment at the receiving compartment maximum condition (FIG. **4**) and flow from the hot to the receiving compartment at the hot compartment maximum volume condition (FIG. **5**). This dual unidirectional valve may be seen as redundant at the receiving compartment maximum condition because the pressure transfer valve (**170**) will also operate at this juncture. So one of these mechanisms may be removed or they may both be employed as a redundancy-based safety precaution.

[0055] When the hot water compartment has reached its maximum volume the circulation of water is enabled by the min/max valve allowing water to flow from the hot compartment to the receiving compartment. Due to the preferred construction as shown, the coldest water in the hot compartment will be pushed into the receiving compartment.

[0056] A sensor (**141**) may monitor the water temperature at the bottom (lowest temperature water) and if this reaches a certain predefined maximum temperature, further heating would be stopped because all the water in the water heater would have reached the required temperature.

[0057] The water heater may also have an outlet (**151**) to a solar heater panel and an inlet (**150**) for the hot water flowing from the solar panel. This is ideally placed in the same generally enclosed volume defined by the wall (**180**) and the member (**120**) as the heating element (**140**) and will operate similarly to allow flow of hot water through the thermostat (**160**) into the hot compartment.

[0058] FIGS. **6***a* and **6***b* show the implementation of a min/max valve **500** to be used in the construction of separation member or layer **640**. This valve is positioned so that it is automatically actuated at compartment min/max conditions to allow flow from the compartment at maximum volume to the compartment at minimum volume but not the other way around. The valve includes a shaft (**600**) that is pressed in a particular direction when a minimum or a maximum volume is reached in the respective compartments. The shaft has flanges (**610** and **620**) that act on covering plates (**611** and **621**) and prevent them from sealing holes below them. FIG. **6**(*b*) shows the hot compartment at a minimum value (FIG. **4**) and the shaft being pressed down to force the plate (**621**) open. Water pressure will automatically lift the plate **611** to allow flow into the hot compartment as shown. If the shaft did not press down, the water pressure would naturally force the plate **621** to block the flow. Movement of the shaft is restricted by means of apertured retention devices **650** and **660**.

[0059] In FIG. **7** a simplified structure **730** is shown for a minimum/maximum valve which functions when the hot compartment is receiving hot water through the thermostat (**160**), (action one) and when the hot compartment is at maximum to allow circulation of water from the hot to the receiving compartment (action two). In this embodiment the following assumptions are made—for action one: a separation element **700** has a slightly negative buoyancy so it tends to enlarge the hot compartment and is only prevented from doing so due to the lack of inflow to fill such larger volume. If the thermostat (**160**) opens to allow hot water into the hot compartment, the hot compartment will enlarge rather than force water through a piped opening (**710**). However, once the hot compartment is at a maximum volume, water will automatically be forced through the opening **710** and allow circulation. The opening is, however, small when compared with outflow from the heater which occurs when a tap or faucet is opened and this, together with the sealing effect of a plate **720** over the piped opening (**710**) to block all flow, will force the hot compartment to shrink when a tap is opened. This prevents cold water from the receiving compartment flowing into the hot compartment through the opening **710** rather than, as required, through the thermostat or pressure transfer valves (**160** and **170**).

[0060] If the separation layer **700** is neutrally buoyant then the buoyancy can be adjusted through the weight of the valve structure (**730**) to achieve negative buoyancy. A slightly negative buoyancy is not a problem for enlarging the receiving compartment due to the ample force available from the mains water pressure in the system. On the other hand the force available from the water temperature stratification (rising hot water) is usefully aided by the negatively buoyant separation layer.

[0061] In another embodiment the water heater **900** is divided into several compartments (N). FIGS. **8***a* to **8***c* show an example with four compartments **993**, **994**, **955** and **996**. The compartments can be fixed in size and are separated by elements **990**, **991** and **992** as shown in FIG. **8**(*a*). These separation elements preferably offer good heat insulation properties. Each compartment allows water flow from an upper zone to a lower zone of a next compartment through a respective link **902**, **903**, **904**. The link **902** has an entry point (**906**) and an exit point (**907**). The entry and exit denominations refer to operation when hot water is discharged for normal type use from the water heater. When in heating mode these aspects may be reversed.

[0062] This mechanism will prevent water, which enters to replace hot water which is discharged from immediately mixing with water in the water heater and thereby reducing the temperature of all the water. The benefit of the invention in this respect is that a) if a limited amount of hot water is used, the water in the compartment used for discharging the hot water (discharging compartment (**996**) may have water unaffected by the temperature of the replacement water from the main supply (or at least a limited effect), and b) a limited amount of water is needed before the preferred energy source (such as solar **970** for example) becomes available, only a reduced amount of water can be heated with an alternative source such as for example a mains power (**910**). This fits the example of a solar water heater where a lot of hot water is used in the evening for bath and shower purposes, but a limited amount of hot water is also needed in the morning for uses like washing and shaving etc.

[0063] In FIG. **8**(*a*) hot water for normal use is discharged through a pipe (**905**) and replacement water enters from a main water supply through an entry point (**901**). In a horizontal position the effect of water stratification (hot water rising) results in the hottest water from each compartment being discharged into the next compartment through the linking mechanisms (pipes **902**, **903** and **904**) (or more if more compartments). In the discharging (last) compartment (**996**) the heating element works with electricity. Although electricity is shown as the heating source (**910**), this may be another source such as, but not limited to, LPG (low pressure gas, liquid petroleum gas). The mechanical construction is very simple. It is augmented with some control mechanisms in order to optimize operation. Normal elements that are part of any water heater which are known are not shown such as, for example, a grounding mechanism, a pressure release valve, outer insulation and the like. If the water heater was used vertically mounted the insulation layers and linking pipes would work more or less the same, but the heating element **910** must be positioned closer to the bottom of the cavity, for example close to an outlet **909**.

[0064] FIG. **8**(*a*) also shows temperature measurement elements (**950**, **951**), a motor **952** to force water flow when required, a valve (**953**) to control flow of water through a link (**912**), a link (**913**) to allow water flow from the receiving compartment(**993**) to the discharging compartment (**996**), and a solar heating mechanism (**970**). The position of the motor/pump (**952**) may be vertical. For example an alternative to the construction in FIG. **8**(*a*) is to put the motor between the solar panel (**970**) and the link (**913**) with another valve where the motor is shown in FIG. **8**(*a*). This will allow the control to create a circulation of water through the solar panel until a desired temperature is reached before letting it flow into the water heater compartment through an outlet (**911**). The solar heater may be an alternative source of energy. The alternative source of energy is in some embodiments not available all the time.

[0065] The operation when the water heater is full of hot water and water is discharged is as follows: water flows through an outlet (**905**) on user demand (opening of tap). The water is replaced with ambient temperature (typically much colder) water flowing in through the entry point (**901**) into the receiving compartment (**993**). At the same time the same amount of the hottest water from the receiving compartment flows through the link (**902**) into the next compartment **994**, and so on through all the compartments until water flows through the link (**904**) into the discharging compartment **996** to replace the discharged hot water. All of this happens under pressure from the main water supply. In this process the links to the external energy source for heating (or pipes outside the water heater) e.g. **912**, **914** play no part.

[0066] For heating water: assume the sun is shining brightly and the solar heater (**970**) is in operation and delivers heat that is transferred to water passing through it. The availability of solar power is monitored (e.g. using a light detector, a Voltaic solar panel etc.) by a control unit (**960**) and the motor (**952**) is activated under control of the control unit (**960**). In one embodiment the heated water flows into the discharging compartment (**996**) through the opening (**911**). This water flow forces the coldest water in the compartment **996** through the outlet (**909**) into the next compartment **995** and so on until water flows through the opening (**906**) into the receiving compartment (**993**). In an improved embodiment the control unit **960** monitors the temperature at (**951**) and controls the motor (**952**) speed in order to make sure the water is heated to a predetermined temperature in the solar heater. This can be done in different ways. In one technique a fixed speed motor (**952**) is used for the control unit (**960**) to control the opening of a valve (**953**) to allow circulation through a pipe (**912**) back through the solar heater (**970**). In this case the motor must be moved to between the solar heater and the pipe (**912**) in the link (**914**).

[0067] When the temperature sensors (**951**) and (**952**) measure maximum temperatures and the motor is running fast it can be assumed that the water heater is fully heated. A temperature sensor at a location (**957**) may deliver a more direct metric as it is responsive to the coldest water from the receiving compartment.

[0068] If water is to be heated through electricity (**910**) (or by other means) there are two options in this embodiment of the invention. The first is to heat only a limited amount of water e.g. in the discharging compartment only. The control unit monitors the temperature sensor (**950**) and if the temperature is too low, it activates element (**910**) to heat the water.

[0069] The control unit can also heat all the water in the water heater by activating the heater element (**910**) and the motor (**952**) to force water to circulate through all the compartments. Again the temperature sensors can be monitored to determine when to stop.

[0070] If the water can freely flow through the solar heater element (e.g. without losing heat when it is cold outside) the link (**912**) and the valve (**953**) are not required. Otherwise the valve can be opened to ensure flow of almost all water from the compartment (**993**) through a pipe (**913**) goes through the link (**912**) past the motor (**952**) into the compartment (**996**). The speed of the motor can be controlled by the control unit to be optimized for heating the water in compartment (**996**) such that the water flowing back through the link (**904**) is at a desired temperature. Flow may be stopped if the heating is not enough or if heat is being lost.

[0071] The temperature sensors can be monitored by the control unit to ensure the water heater is filled with water at a pre-determined temperature. This will allow the control unit to check the water temperature at the end of the sun day and, for example, decide to provide additional heating on a cloudy day when solar power is inadequate to heat the required amount of water to a predetermined temperature.

[0072] In FIG. **8**(*b*) further valves (**954**, **955**, **956**) are installed. These can be controlled to heat the compartments **995** and **996**, or three components etc. This will allow a sophisticated control unit to optimize energy usage and hot water availability. A control unit may actually be programmed to learn usage patterns at a particular installation (so called artificial intelligence) in order to offer the best energy usage for each household, business etc. For business usage, weekends may for example be targeted so that only a single compartment is heated. During the week, more compartments may be heated.

[0073] When a preferred energy (heat) source is used in conjunction with an auxiliary heat source such as for example electricity or LPG heating, it is important to take the specific time of day into account when deciding to activate the auxiliary heat source. It is different when a low level of hot water is detected in early evening (i.e. little hope of the solar heater changing the situation) versus early morning with the sun just up, people normally off to work and plenty of time for the solar panel to do its work.

[0074] As such a decision taken during early evening may be to heat several compartments to a predetermined heat level, but in early morning it will typically be decided to heat the minimum volume of water.

[0075] The water heater (**900**) may also be installed vertically with the cold inlet at the bottom. The electricity heat element (**910**) should then preferably be closer to the bottom.

[0076] Although the primary target is for the benefits offered in situations with intermittent preferred power source energy (different time slot tariffs, solar power etc.) the invention also offers power savings for office blocks where reduced usage of hot water is expected over weekends or holidays. In this case a reduced number of compartments in the water heater are heated. In FIG. **8**(*c*) the last separation layer (**992**) is made thicker to offer more heat insulation for the situation when only the last compartment is heated. This method can be used with or without a solar panel i.e. a regular water heater operating with gas or electricity can be used in this way to reduce energy usage.

[0077] In another embodiment the water heater may be adapted to use only the water heat stratification principle to cycle water through the water heater and the solar panel and not require any electric or other motorized pump to force the flow. This will require a link from the cold area of the water heater (see pipe **913** in FIG. **8**(*c*)) to the hot side of the solar heater, and a link from the hot compartment to the cold (inlet) side of the solar heater.

[0078] FIGS. **9**(*a*) and **9**(*b*) are side views of a horizontal container **1000** which is divided by a movable separator **1002** in a hot compartment **1004** and a cold compartment **1006**. The separator is movable, in accordance with the principles which have been described, between limiting positions determined by stops **1012** and **1013** (maximum hot water compartment) and **1010** and **1011** (minimum hot water compartment).

1. A water heater with multiple fixed volume compartments separated from one another by respective separation walls and allowing water to flow from a top of one compartment to another compartment when water flows out of the water heater in normal operation, characterized by a heat source that functions according to at least one of the implementations in the following group:

a) a structure to heat the water in a selected number of compartments only and not heat the water in all the compartments;

b) a structure to use a preferred heat source and an auxiliary heat source, wherein the auxiliary heat source is only used when the preferred heat source does not provide enough heat to comply with hot water demand from the water heater; and

c) a structure to use a preferred heat source and an auxiliary heat source in a way to minimize the use of the auxiliary heat source but still provide good availability of hot water from the water heater to satisfy user demand, with the preferred heat source of an intermittent nature.

2. The water heater of claim **1** wherein a control unit monitors the temperature in the water heater at least at one location and controls the heating of one or more compartments of water in a way to provide sufficient hot water for normal average usage but in an energy efficient manner by not heating more water than what would typically be needed in a time period to follow.

3. The water heater of claim **2** wherein a decision for heating multiple compartments is taken with specific consideration of the time of day or day of the week.

4. The water heater of claim **1** wherein a control unit monitors the temperature in the water heater at least at one location and controls the heating of one or more compartments of water in a way to provide sufficient hot water for normal average usage but in an energy efficient manner by not heating more water than what would typically be needed in a time period to follow.

5. The water heater of claim **1** where the preferred heat source is solar and the auxiliary heat source is electricity or LPG and wherein a control unit monitors the water temperature in the water heater at least at one location and controls the auxiliary source heating of water in accordance with the availability of solar energy and time of day to provide sufficient hot water for average usage.

6. The water heater of claim **1** wherein water flows from a top zone of one compartment to a lower zone of another compartment.

7. The water heater of claim **1** wherein the separation walls between compartments provide good heat insulation.

8. The water heater of claim **1** wherein the heat source functions according to implementation **1**a.

9. The water heater of claim **1** wherein the heat source functions according to implementation **1**b.

10. The water heater of claim **1** wherein the heat source functions according to implementation **1**c.

11. The water heater of claim **1** wherein the heat source functions according to implementations **1**a and **1**b.

12. The water heater of claim **1** wherein the heat source functions according to implementations **1**a and **1**c.

13. The water heater of claim **2** wherein water flows from a top zone of one compartment to a lower zone of another compartment.

14. The water heater of claim **3** wherein water flows from a top zone of one compartment to a lower zone of another compartment.

15. The water heater of claim **4** wherein water flows from a top zone of one compartment to a lower zone of another compartment.

16. The water heater of claim **5** wherein water flows from a top zone of one compartment to a lower zone of another compartment.

17. The water heater of claim **2** wherein the separation walls between compartments provide good heat insulation.

18. The water heater of claim **3** wherein the separation walls between compartments provide good heat insulation.

19. The water heater of claim **4** wherein the separation walls between compartments provide good heat insulation.

20. The water heater of claim **5** wherein the separation walls between compartments provide good heat insulation.

* * * * *