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(54) HEAT PUMP WATER HEATER

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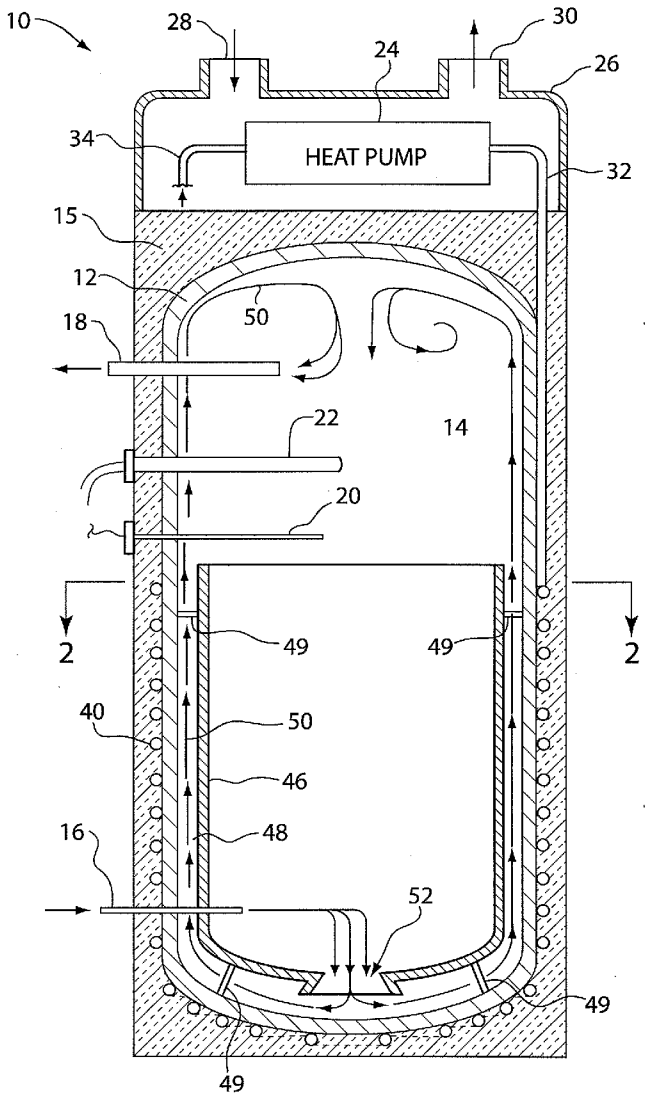
(57) **ABSTRACT**

A heat pump water heater includes a heat pump which generates a hot refrigerant and a water tank for water to be heated. The water tank includes a surrounding wall which is preferably cylindrical and a bottom portion. An inner sleeve is located in the bottom portion of the water tank, and is spaced from the bottom portion and an adjacent portion of the surrounding wall of the water tank, whereby a passageway is provided about the inner sleeve. The inner sleeve also includes an opening at a bottom thereof. A circulation system puts the heated refrigerant in a heat exchange relationship with the water in the passageway, causing heating of the water therein and, due to natural convection, movement of the heated water to a higher position in the water tank and a resultant flow of cooler water into the passageway through the bottom opening of the inner sleeve.



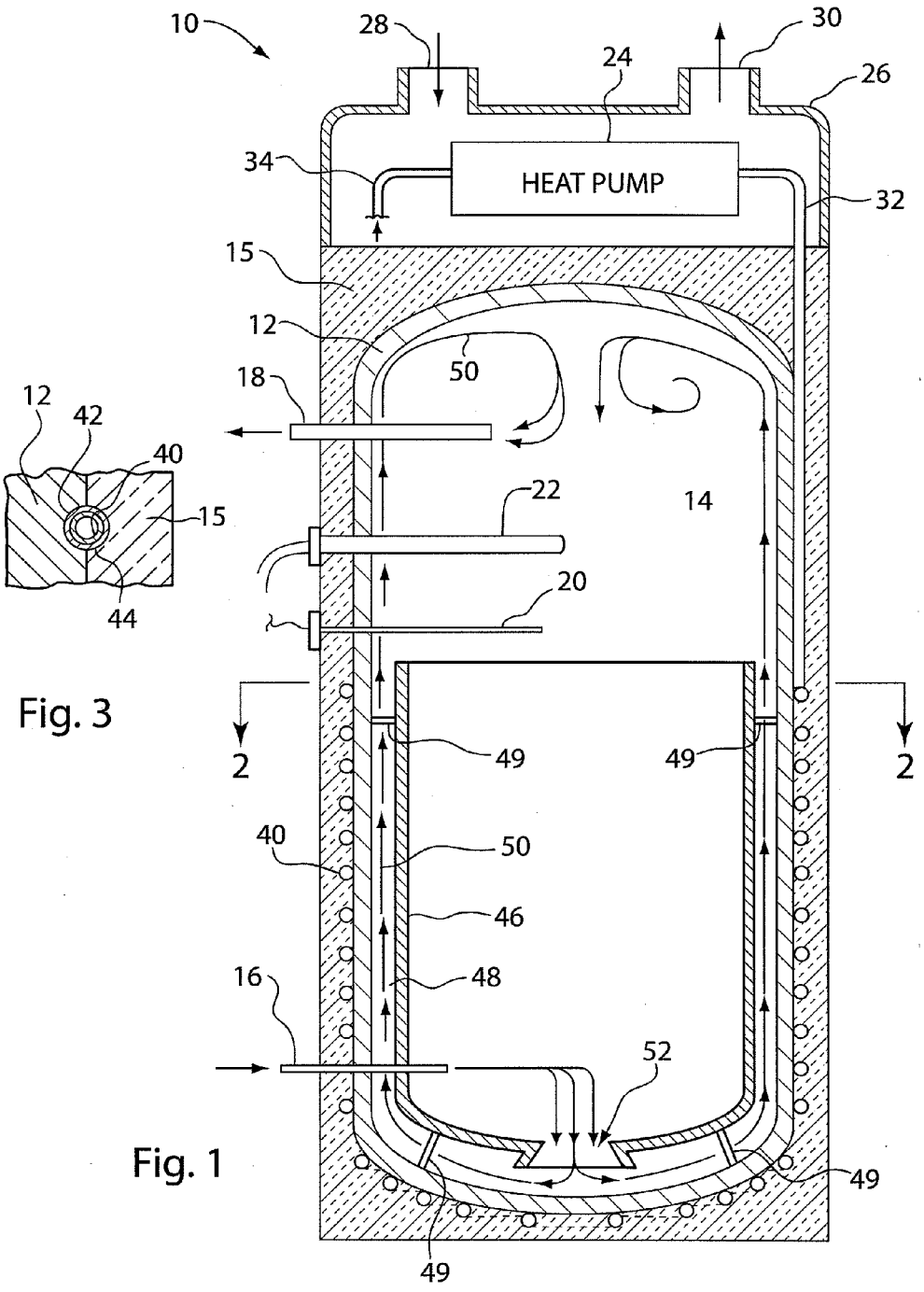

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Fig. 3

Fig. 1

Fig. 2

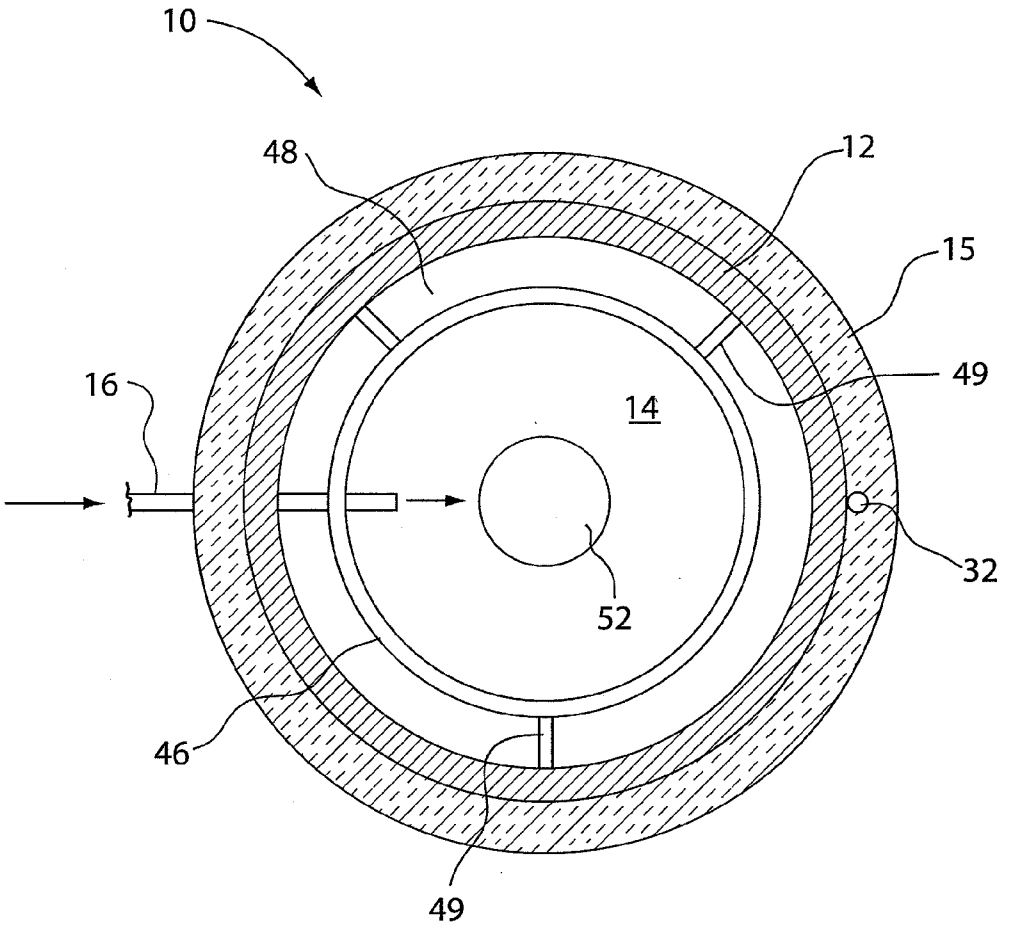


Fig. 4

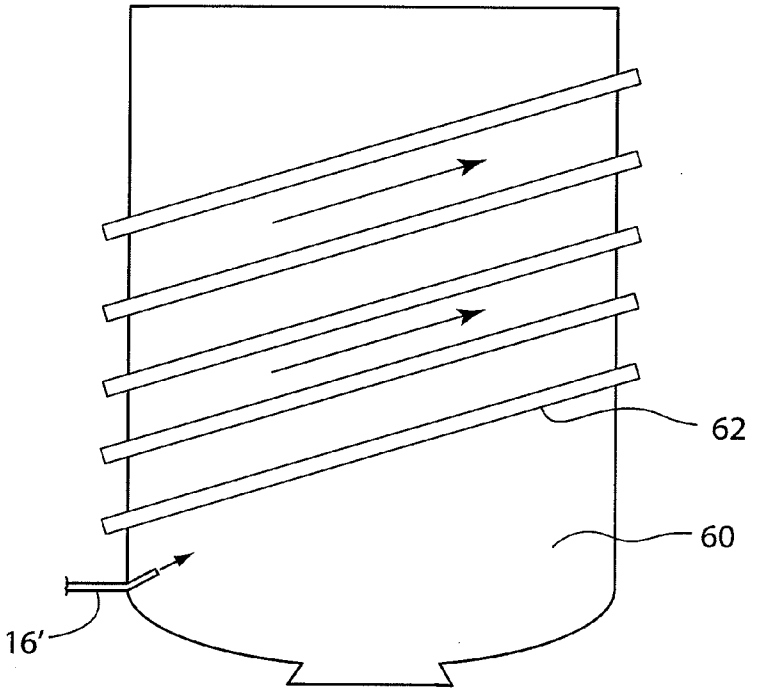


Fig. 5

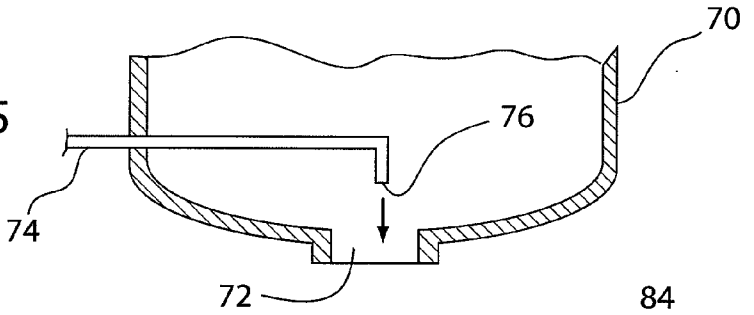
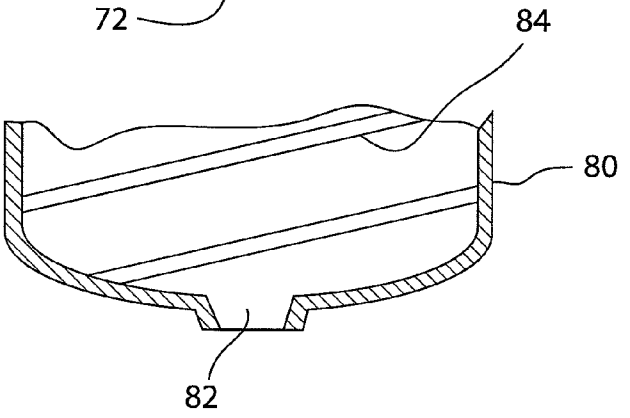


Fig. 6



HEAT PUMP WATER HEATER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. Provisional application 61/323,584, filed Apr. 13, 2010 and entitled Heat Pump Water Heater (which is hereby incorporated by reference).

BACKGROUND OF THE INVENTION

[0002] The heating of water for residential usage is generally 30% to 40% of the monthly energy costs of a traditional household. With a renewed interest in improving energy efficiency and the saving of fossil fuels, new innovations in water heaters are being developed to increase efficiency. The latest technology in water heater design is often referred to as, "all in one heat pump water heaters". Water heater of this design include small heat pumps with attached storage tanks. This design currently provides the most efficient method of heating water for residential or commercial applications.

[0003] There are many methods of affecting heat transfer to water from a heat pump. Although almost all heat pump water heaters are more efficient that conventional resistant heat water heaters, each design has its own assets (and liabilities) in terms of efficiency and longevity. One prior art design involves the use of a copper tube coiled within a water storage tank that transfers heat from the compressor refrigerant flowing through the copper tube to the potable water in the tank to heat the water in the tank. This type of internal tube heat transfer is fairly efficient, however the single tube creates a safety hazard if there is corrosion or rupture in the tube causing contamination of the potable water by the refrigerant. Another variation of this prior art to overcome the contamination makes use of a double wall refrigerant tube which is also coiled within the potable water. The double wall tube is designed to protect the potable water even if there is a rupture in either tube. Any rupture in either tube generally causes the unit to shut down; and since the refrigerant coils are not replaceable, such a rupture renders the unit a total loss.

[0004] Internal heat transfer tubes also have a great likelihood of attracting minerals from contact with potable water. This contact can lead to corrosion, and calcium and mineral build up on the tubes, which decreases the heat transfer efficiency of such internal tubes.

[0005] Another prior art method used to overcome the contamination problem is to have the heat transfer take place outside of the tank, within the heat pump unit. These types of units generally avoid the contamination problems, but are not as efficient and cause the incoming cold water to mix with the hot water in the tank, lowering the overall temperature in the tank as the water is being heated. This method is also not very efficient due to the amount of heated surface area upon which the tank water can come into contact with the cold water, and the reduced efficiency of the heat transfer between the heat coils and the outer tank.

[0006] The present invention departs from the traditional heap pump water heater designs, and is an improved way to transfer heat from the heat pump to the water with improved efficiency and reduced risk of contamination and calcium build up.

BRIEF SUMMARY OF THE INVENTION

[0007] In view of the foregoing disadvantages noted to be inherent in the prior heat pump water heater designs, the present invention is designed to be very efficient in the heating of water and to completely eliminated the chance of the potable water being contaminated by the heat transfer process.

[0008] Thus, in accordance with the present invention, there is provided a heat pump water heater including a heat pump which generates a hot refrigerant and a water tank in which water to be heated is contained. The water tank includes a lower portion defined by a bottom wall and a surrounding wall which is preferably cylindrical and thus which extends upwardly from bottom wall. Also provided is an inner sleeve located in the lower portion of the water tank. This inner sleeve is spaced from the bottom wall and an adjacent portion of the surrounding wall, whereby a passageway is provided about the inner sleeve. The inner sleeve also includes an opening at a bottom thereof. Finally, a circulation system is provided by which the heated refrigerant from the heat pump is put in a heat exchange relationship with the water in the passageway, causing heating of the water in the passageway and, due to natural convection, movement of the heated water to a higher position in the water tank and a resultant flow of cooler water into the passageway through the bottom opening of the inner sleeve.

[0009] In a preferred embodiment, the circulation system includes tubing which receives the hot refrigerant from the heat pump and which serves to heat the water in the passageway. In this preferred embodiment, the water tank also includes grooves in an outside surface of the adjacent portion of the surrounding wall of the water tank in which the tubing is located. The tubing is disposed in a spiral pattern in the grooves on the outside surface of the water tank. In an alternative embodiment, the outside surface of the water tank is smooth and the tubing is spirally wound and preferably also in contact therewith.

[0010] For better efficiency, the tubing is preferably provided with an outer heat transfer promoting covering; and as desired, an outer protective covering which may as well promote heat transfer.

[0011] If desired, the inner sleeve can be provided with a spiral ridge thereabout, to promote a spiral pattern of water flow through the passageway for better heat transfer.

[0012] The heat pump water heater also preferably includes a water outlet pipe by which heated water is removed from a top portion of the water tank. Then, there is provided a water inlet pipe by which water to be heated is introduced into the water tank. This water inlet pipe includes an outlet in the water tank which is inside of the inner sleeve and vertically adjacent to the bottom opening of the inner sleeve. More preferably, the outlet of the inlet pipe directs the introduced water downwards towards the bottom opening of the inner sleeve.

[0013] Various bottom openings of the inner sleeve are possible, including one which is flared downwardly and outwardly, one which is flared downwardly and inwardly, and one which is flared straight downwardly.

[0014] If desired, the inner sleeve includes a spiral ridge on an inside surface thereof.

[0015] One aspect of this invention is that the passageway between the outer water tank and inner sleeve will cause the water to remain in closer and longer contact with the heated wall of the water tank. This contact results in transferring of more heat to the water in the passageway between the heated wall of the water tank and the inner sleeve, increasing the heat transfer and efficiency over a traditional coil tank.

[0016] Another aspect of this invention is that it causes the heated water to be separated from the rest of the water in the water tank during heating, thus providing the hottest water to the hot water outlet when it is located (as usual) at the top portion of the water tank (either centrally or at upper sides of the water tank near the top).

[0017] Another aspect of this invention is that the water that is heated in the passageway between the outer water tank and the inner sleeve is always convecting upward to the top of the water tank where the hot water outlet is preferably located, while at the same time the (relatively) cooler water located at the top of the water tank is thus displaced and flows downward to start the heating cycle of that cooler water again.

[0018] Another aspect of this invention is that the heated water concentrated between the outside wall of the water tank and the inner sleeve will create convection causing: a) the heated water to rise to the top of the water tank, b) the cooler water at the top of the water tank to circulate downward into the cavity inside of the inner sleeve, c) the cooler water to convect down and pass through the opening in the bottom of the horizontal or curved bottom of the inner sleeve, and d) the cooler water to be convected upward between the water tank and inner sleeve to effect a rapid heating of the cooler water. This thus completes a circulatory cycle of the hot and cooler water, causing the water to be heated more efficiently in the space or passageway between the outer water tank and inner sleeve.

[0019] Another aspect of this invention is that the opening in the bottom of the inner sleeve allows the cooler water in the tank to be drawn down through this opening as the heated water in the space between the outer tank and inner sleeve is heated and rises, causing the cooler water to circulate downward. The bottom of the inner sleeve can be flat or curved as to cause the cooler water to easily enter the opening and be convected outward and upward passing through the passageway between the outer tank and inner sleeve.

[0020] Another aspect of this invention is that the bottom opening of the inner sleeve can be of any size and have any number of openings to improve the convection flow. This bottom opening can also have a collar to the concave or convex side to improve the flow of the cold water through the opening.

[0021] Another aspect of this invention pertains to an improvement over the traditional inside refrigerant coil heating method. Traditional water heaters have different types of heating elements inside the tank. These elements are susceptible to erosion, calcification and general dissolution. Copper heat transfer coils inside a potable water tank are known to attract minerals, to become calcified, and to have a lessened efficiency. Although anodic rods are made to prevent corrosion within tanks, these may or may not be used with the heat pump water tank of the present invention. These rods are rarely maintained or serviced in a timely manner.

[0022] Other features and advantages of the present invention are stated in or apparent from detailed descriptions of presently preferred embodiments of the invention found hereinbelow.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0023] FIG. **1** is a cross sectional elevation view of a heat pump water heater of the present invention.

[0024] FIG. **2** is a cross sectional top view of the heat pump water heater depicted in FIG. **1**.

[0025] FIG. **3** is a broken out portion of the water tank wall depicted in FIG. **1**.

[0026] FIG. **4** is an elevation view of an alternative water sleeve of the present invention.

[0027] FIG. **5** is a cross sectional elevation view of a second alternative water sleeve of the present invention.

[0028] FIG. **6** is a cross sectional elevation view of a third alternative water sleeve of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] With reference now to the drawings in which like numerals represent like elements throughout the views, there is disclosed in FIGS. **1** and **2** a heat pump (hereafter HP) water heater **10** according to the present invention. HP water heater **10** includes a cylindrical water tank **12** where potable water **14** is heated and stored. Water tank **12** can be of any shape, although a rounded end cylindrical shape is usually the most effective, and preferably water tank **12** includes insulation **15** thereabout as shown. Water tank **12** can also be manufactured out of any number of suitable materials including, but not restricted to: stainless steel, galvanized steel, ceramic coated steel, or plastic. Generally, water tank **12** is provided with a water inlet pipe **16** for the water to be heated and a water outlet pipe **18** to enable the hot water **14** in water tank **12** to be withdrawn for use. Water tank **12** can further contain any number of access openings for any number of accessories such as, but not limited to, a temperature sensor **20** and an auxiliary heating element **22**.

[0030] Conveniently, a suitably driven heat pump **24** is located in a housing **26** provided on top of (or otherwise adjacent to) water tank **12**. Housing **26** has an air inlet **28** and an air outlet **30** positioned and sized as needed. Heat pump **24** circulates a working fluid or refrigerant via a hot outlet tube **32** and a cold return tube **34**.

[0031] In accordance with the present invention, a spiral tubing **40** for circulating heated refrigerant from hot outlet tube **32** and back to cold return tube **34** is placed in contact with the outer wall of tank **12**. Tubing **40** is conveniently round, but can be flat or oval for to provide a greater heat transfer surface area. As shown in FIG. **1**, this contact of tubing **40** is preferably accomplished by putting tubing **40** in a spiral groove **42** located around the outside surface of tank **12**, thus providing a large surface area for good heat transfer. Tubing **40** is at least inside of insulation **15**. Tubing **40** is also preferably formed into coils located in grooves **42** around the bottom of water tank **12** as shown in FIG. **1**, and from which the cooled refrigerant is fluidly connected to cold return tube **34**. The coils of tubing **40** can also be coated with a coating **44**, as shown best in FIG. **3**, which will more readily effect heat transfer from the coils to the material of water tank **12** and thus to water **14**. Coating **44**, or a separate (different) protective coating, may also be used to create a barrier between water tank **12** and tubing **40** to avoid any electrolytic reaction between tubing **40** and water tank **12** that would otherwise cause corrosion of either material.

[0032] HP water heater **10** of the present invention also includes an inner cylindrical sleeve **46** manufactured out of metal, ceramic or plastic that preferably follows the general contours of the inside of tank **12**. Although inner sleeve **46** can be made out of any number of materials, these materials must be safety approved for use with potable water along with all of the other components of HP water heater **10**. In addition, inner sleeve **46** preferably (but not necessarily) has an insulating value, in order to allow heated water **14** on the outside

thereof (in passageway **48** as noted below) to more efficiently retain the heat transferred thereto by tubing **40** as water **14** moves convectively upward, otherwise some of that heat would be lost through contact with inner sleeve **46** and to the cooler water **14** traveling downward there through. It will be appreciated that inner sleeve **46** is spaced from the adjacent portions of water tank **12** by suitable braces **49** or the like, which spacing creates a separation passageway **48** between the side and bottom surfaces of water tank **12**. With the provision of passageway **48**, water **14** therein can naturally circulate via convection as shown by arrows **50**, and water **14** to be heated therein is kept in close contact with the heat transferring wall of tank **12** for a more efficient transfer of heat to water **14**. The top of inner sleeve **46** is open as shown, while the bottom of inner sleeve **46** can be bowed outwardly or concave (as shown). Of course, the bottom of inner sleeve **46** could also be bowed inwardly or convex, or flat as desired. At the bottom of inner sleeve **46** there is provided an outlet opening **52** which is flared outwardly in this embodiment and through which water **14** in water tank **12** flows as shown by arrows **50**. A plurality of bottom openings of inner sleeve **46** would also be possible if desired.

[0033] There is also provided, through the side of water tank **12** and through the side of inner sleeve **46**, an inlet pipe **54** for cold make-up or supply water to be added to water tank **12**. Preferably, inlet pipe **54** is positioned near the bottom surface or lower side of inner sleeve **46**, so that water flowing into water tank **12** is close to outlet opening **52** and hence so that the (cooler) water from water inlet pipe **16** will be immediately drawn down through outlet opening **52** and enter into passageway **48** to be heated immediately and before substantial mixing with the remaining (hot) water **14** in water tank **12**. Alternatively, an inlet pipe **16'** can be positioned so that the cold water enters passageway **48** directly and preferably at the bottom thereof (as shown in FIG. **4**), rather than through outlet opening **52**. Inlet pipe **16** can also have an outlet (as shown in FIG. **4**) which directs the incoming (cold) water in the direction of outlet opening **52**, to more efficiently cause the incoming (cooler) water therefrom to flow down through outlet opening **52** and into that part of passageway **48** at the bottom of inner sleeve **46**. From the bottom of water tank **12**, it will be appreciated that the (cooler) water **14** in passageway **48** is immediately heated by tubing **40**, and thus flows by convection upwardly in water tank **12**. This upward flow is an efficient way to heat water **14**, since water **14** to be heated is contained in passageway **48** for the entire height thereof (i.e., between inner sleeve **46** and the wall of water tank **12**) to achieve a maximum contact of water **14** with the heated wall of water tank **12** as water **14** flows by convention upward in passageway **48**, with a resultant maximum heat transfer made to water **14** in passageway **48**.

[0034] It will be appreciated that water outlet pipe **18** of water tank **12** is located near the top of water tank **12** or in the side of water tank near the top, where the hottest water **14** will be located (via convection thereof) and consequently then drawn out for use. It will also be appreciated that the design of passageway **48** between water tank **12** and inner sleeve **46** is such that passageway **48** will discourage the (cooler) water from inlet pipe **16** from mixing with the freshly heated (and hottest) water **14** in passageway **48** rising to the top of water tank **12**. Of course, if there were mixing of the cooler water first, this could result in an undesirable lowering of the overall temperature of water **14** throughout water tank **12**, and in particular at the top of water tank **12** near outlet pipe **18**. Instead, the configuration of water tank **12** keeps the supply of the hottest water **14** in water tank **12** flowing at all times to the top, and with the cooler water **14** being heated first during any heating cycle.

[0035] An alternative inner sleeve **60** for inner sleeve **46** of HP water heater **10** is depicted in FIG. **4**. Inner sleeve **60** includes a spiral ridge or spacer **62** on the outer surface thereof which can be used to maintain inner sleeve **60** with a desired or proper spacing from the inside surface of water tank **12** (not shown) in place of braces **49**. Due to the spiral orientation of ridge or spacer **62** around inner sleeve **60**, ridge or spacer **62** can also (or without any spacing utility) be utilized to promote the flow of water. **14** spirally in passageway **48** (the space between inner sleeve **46** and water tank **12**) and hence to cause water **14** to circulate spirally around passageway **48**. Such a spiral flow in passageway **48** effects more heat transfer due to a longer (spiral) travel length/time while being heated by tubing **48** and the adjacent heated portions of water tank **12** and inner sleeve **60**. As noted above, water inlet pipe **16'** can also be used as shown to additionally (or by itself) promote the spiral flow of water **14**.

[0036] A second alternative inner sleeve **70** is depicted in FIG. **5**. As shown, inner sleeve **70** has an outlet opening **72** which is straight down. In addition, it will be noted that water inlet pipe **74** has a downwardly directed outlet end **76** which directs the water exiting therefrom directly down through outlet opening **72** and hence immediately into the surrounding passageway.

[0037] A third alternative inner sleeve **80** is depicted in FIG. **6**. As shown, inner sleeve **80** has an outlet opening **82** which is flared inwardly at the lower end thereof. In addition, it will be noted that a spiral ridge **84** can similarly be placed on the inside surface of inner sleeve **80** as shown to facilitate a circulation or downward flow of (cold) water **14** to improve initial circulation.

[0038] While the present invention has been described with respect to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that variations and modifications can be effected within the scope and spirit of the invention.

We claim:

1. A heat pump water heater comprising:

a heat pump which supplies a hot refrigerant;

a water tank in which water to be heated is contained, said water tank including a lower portion defined by a bottom wall and a surrounding wall extending upwardly from said bottom wall;

an inner sleeve located in said lower portion of said water tank, said inner sleeve being spaced from said bottom wall and an adjacent portion of said surrounding wall whereby a passageway is provided about said inner sleeve, said inner sleeve also including an opening at a bottom thereof; and

a circulation system by which the heated refrigerant from said heat pump is put in a heat exchange relationship with the water in said passageway, causing heating of the water in said passageway and, due to natural convection, movement of the heated water to a higher position in said water tank and a resultant flow of cooler water into said passageway through said bottom opening of said inner sleeve.

2. A heat pump water heater as claimed in claim **1**, wherein said circulation system includes tubing which receives the hot

refrigerant from said heat pump, said tubing being disposed on an outside surface of said water tank to heat the water in said passageway.

3. A heat pump water heater as claimed in claim **2**, wherein said water tank further includes grooves in the outside surface of the adjacent portion of said surrounding wall of said water tank in which said tubing is at least partially located.

4. A heat pump water heater as claimed in claim **3**, wherein said tubing is disposed in a spiral pattern in said grooves on the outside surface of the adjacent portion of said surrounding wall of said water tank.

5. A heat pump water heater as claimed in claim **2**, wherein said tubing includes an outer heat transfer promoting covering.

6. A heat pump water heater as claimed in claim **5**, wherein said tubing includes an outer protective covering.

7. A heat pump water heater as claimed in claim **1**, wherein said inner sleeve includes a spiral ridge thereabout.

8. A heat pump water heater as claimed in claim **1**, and further including:

a water outlet pipe by which heated water is removed from said water tank; and

a water inlet pipe by which water to be heated is introduced into said water tank, said water inlet pipe including an outlet in said water tank which is inside of said inner sleeve and vertically adjacent to said bottom opening of said inner sleeve.

9. A heat pump water heater as claimed in claim **8**, wherein said outlet of said inlet pipe directs the introduced water downwards towards said bottom opening of said inner sleeve.

10. A heat pump water heater as claimed in claim **1**, wherein said bottom opening of said inner sleeve is flared downwardly and outwardly.

11. A heat pump water heater as claimed in claim **1**, wherein said bottom opening of said inner sleeve is flared downwardly and inwardly.

12. A heat pump water heater as claimed in claim **1**, wherein said bottom opening of said inner sleeve is flared straight downwardly.

13. A heat pump water heater as claimed in claim **1**, wherein said inner sleeve includes a spiral ridge on an inside surface thereof.

14. A heat pump water heater comprising:

a heat pump which supplies a hot refrigerant;

a cylindrical water tank in which water to be heated is contained, said water tank including a surrounding wall and a bottom wall and having a lower portion;

a cylindrical inner sleeve located in said lower portion of said cylindrical water tank, said inner sleeve being spaced from said bottom wall and an adjacent portion of said surrounding wall whereby a cylindrical passageway is provided about said inner sleeve, said inner sleeve also including an opening at a bottom thereof; and

a circulation system by which the heated refrigerant from said heat pump is circulated along the surrounding wall of said water tank and hence put in a heat exchange relationship with the water in said passageway, causing heating of the water in said passageway and, due to natural convection, movement of the heated water to a higher position in said water tank and a resultant flow of cooler water down through said inner sleeve and into said passageway through said bottom opening of said inner sleeve.

15. A heat pump water heater as claimed in claim **14**, wherein said circulation system includes tubing which receives the hot refrigerant from said heat pump, said tubing being disposed on an outside surface of said water tank to heat the water in said passageway.

16. A heat pump water heater as claimed in claim **15**, wherein said water tank further includes grooves in the outside surface of the adjacent portion of said surrounding wall of said water tank in which said tubing is located.

17. A heat pump water heater as claimed in claim **16**, wherein said tubing is disposed in a spiral pattern in said grooves on the outside surface of the adjacent portion of said surrounding wall of said water tank.

18. A heat pump water heater as claimed in claim **17**, wherein said inner sleeve includes a spiral ridge thereabout.

19. A heat pump water heater as claimed in claim **16**, and further including:

a water outlet pipe by which heated water is removed from said water tank; and

a water inlet pipe by which water to be heated is introduced into said water tank, said water inlet pipe

including an outlet in said water tank which is inside of said inner sleeve and vertically adjacent to said bottom opening of said inner sleeve.

20. A heat pump water heater as claimed in claim **19**, wherein said inner sleeve includes a spiral ridge on an inside surface thereof.

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