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(54) Water Heater having Condensing Recuperator and Dual Purpose Pump

(57) A water heater having primary and secondary heat exchanger and a pump to move water between the primary and secondary heat exchangers. The pump may also be used for the purpose of recirculating water within a building. The water heater may be manufactured with a method in which certain steps and components are added to a water heater of a first efficiency to arrive at a water heater having a second efficiency greater than the first efficiency. The additional steps and components may include attaching a condensing recuperator to a traditional power vent water heater.

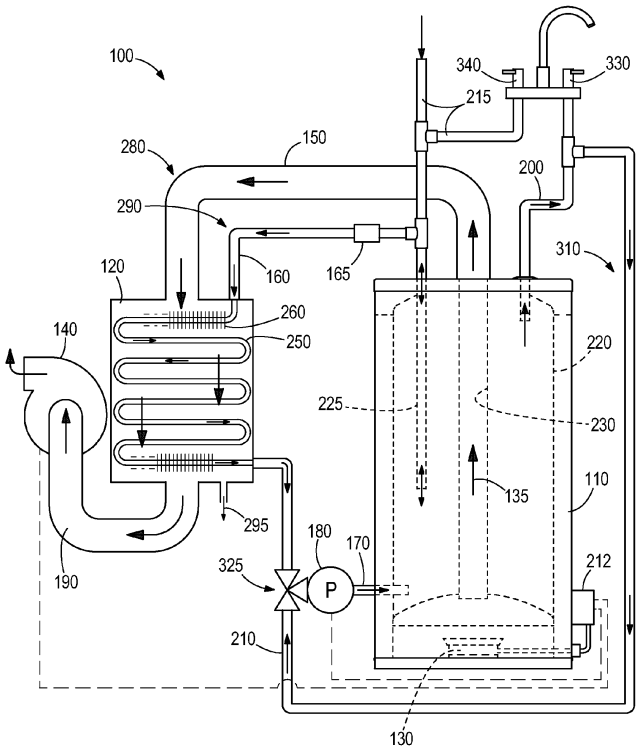

FIG. 1A

EP 2 669 593 A1

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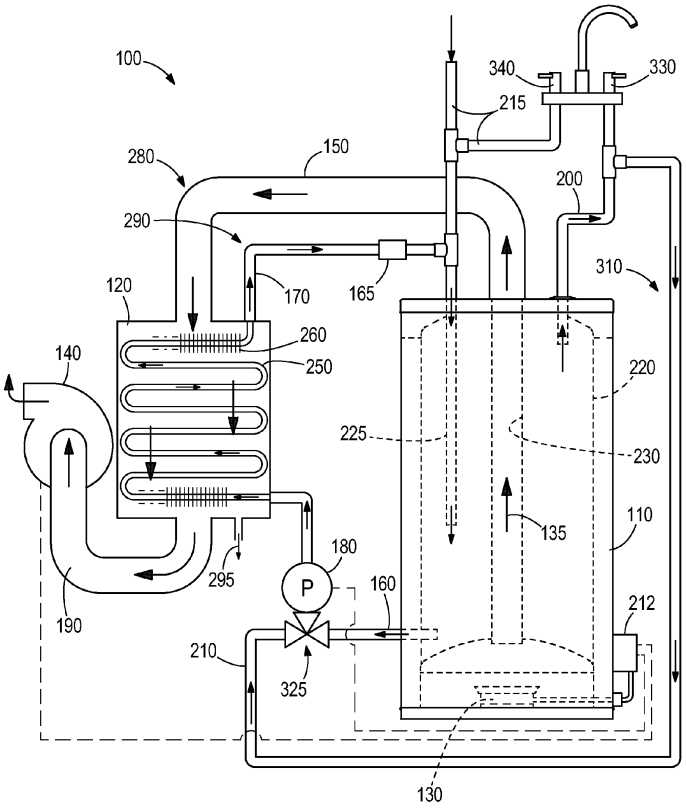
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FIG. 1B

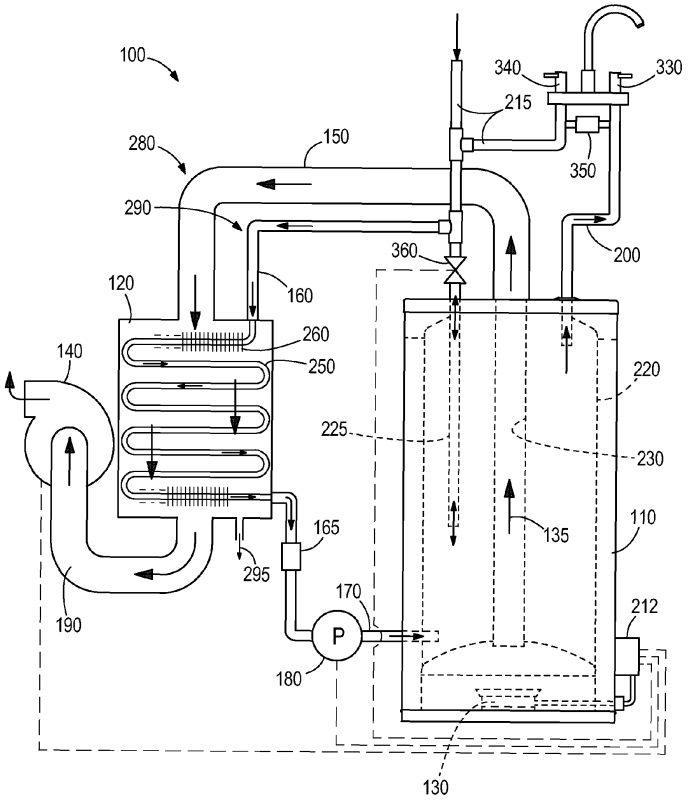
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FIG. 1C

Description

BACKGROUND

[0001] The invention relates to a water heater having primary and secondary heat exchangers and a pump to move water between the primary and secondary heat exchangers. The invention also relates to a water heater in which a pump is used for a first purpose within the water heater and also for the purpose of recirculating water within the building. The invention also relates to a method of manufacturing a water heater, in which a water heater of a first efficiency can be produced on an assembly line, and, with the addition of certain steps, and components the water heater can meet a second efficiency greater than the first efficiency.

SUMMARY

[0002] According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

[0003] In one embodiment, the invention provides a water heater comprising: a tank-type water heater having a tank adapted to store water, a flue extending through the tank; a source of hot gas, the hot gas flowing through the flue to heat water in the tank; a flow-type water heater receiving the hot gas from the flue and heating water with the hot gas; and a pump for moving water from the tank, through the flow-type water heater, and back to the tank.

[0004] In some embodiments, the water heater is adapted for use in a building having a hot water supply pipe communicating directly with the tank; and the pump also circulates water from the tank through the hot water supply pipe and back into the tank to maintain a ready supply of hot water in the hot water supply pipe. In some embodiments, the flow-type water heater is a condensing water heater. In some embodiments, the temperature of the hot gas does not exceed 600 °F. In some embodiments, the hot gas comprises products of combustion.

[0005] The invention also provides a water heater communicating with a hot water supply pipe, the water heater comprising: a source of hot gas; a heat exchanger for transferring heat from the hot gas to water; and a pump for accomplishing a first purpose related to the water heater; wherein the pump is also used for a second purpose that includes circulating water through the hot water supply pipe and back to the water heater to maintain a ready supply of hot water in the hot water supply pipe.

[0006] In some embodiments, the source of hot gas includes a fuel-fired burner; and the hot gas includes products of combustion. In some embodiments, the water heater further comprises a tank-type water heater including a tank for holding the water; the heat exchanger includes a flue extending through the tank; and the hot gas flows through the flue to heat the water in the tank. In some embodiments, the heat exchanger further comprises a flow-type water heater through which the hot gas flows and through which the water flows; and the hot gas heats the water in the flow-type water heater. In some embodiments, the flue is a primary heat exchanger through which the hot gas flows first; and the flow-type water heater is a secondary heat exchanger through which the hot gas flows after flowing through the primary heat exchanger. In some embodiments, at least one of the primary and secondary heat exchangers is a condensing water heater. In some embodiments, the first purpose of the pump is to move water from the tank-type water heater through the flow-type water heater.

[0007] In some embodiments, the heat exchanger includes a primary heat exchanger and a secondary heat exchanger; the primary heat exchanger uses heat from the hot gas to heat the water; and the secondary heat exchanger receives the hot gas from the primary heat exchanger and uses heat from the hot gas to heat the water; and the first purpose of the pump is to circulate water through the primary and secondary heat exchangers. In some embodiments, at least one of the primary and secondary heat exchangers is a condensing heat exchanger. In some embodiments, both of the primary and secondary heat exchangers are condensing heat exchangers.

[0008] The invention also provides a method for manufacturing a water heater comprising the steps of: (a) assembling a tank-type water heater having a tank adapted for containing water, a flue extending through the tank, and a fuel-fired burner for creating products of combustion to flow through the flue and heat water in the tank; (b) deciding whether to manufacture a high efficiency water heater; and (c) if manufacturing a high efficiency water heater, (i) providing a condensing flow-type water heater; (ii) providing a pump; (iii) plumbing the flow-type water heater and the pump to the tank to enable the pump to move water from the tank, through the flow-type water heater, and back to the tank; and (iv) communicating the flue with the flow-type water heater to conduct products of combustion from the flue through the flow-type water heater to heat water in the flow-type water heater.

[0009] In some embodiments, providing a pump includes providing a pump enabled to circulate water from the tank, through a building recirculation system, and back to the tank, in addition to moving water from the tank, through the flow-type water heater, and back to the tank. In some embodiments, step (c) includes providing a control system that enables operation of the pump during operation of the burner and independent of operation of the burner.

[0010] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1A is a schematic illustration of one ar-

rangement of the water heater according to the present invention

[0012] Fig. 1B is a schematic illustration of an alternative arrangement.

[0013] Fig. 1C is a schematic illustration of an alternative arrangement.

[0014] Fig. 2 is a perspective view of a top-mounted recuperator arrangement of the present invention.

[0015] Fig. 3 is a perspective view of a side-mounted recuperator arrangement of the present invention.

DETAILED DESCRIPTION

[0016] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

[0017] Figs. 1A, 1B, and 1C (collectively, "Fig. 1") illustrate a high-efficiency water heater 100 that includes a tank-type water heater 110, a flow-type water heater 120, a source of hot gas 130 that produces hot gas 135, a blower 140, a hot gas connecting conduit 150, a water connecting conduit 160, a check valve 165, a water return conduit 170, a pump 180, a hot gas exhaust conduit 190, a hot water supply pipe 200, a recirculation pipe 210 (Figs. 1A and 1B only), and a controller 212. The water heater 100 receives cold water from a source of cold water (e.g., municipal or well) through a cold water supply pipe 215, and heats the water for potable use.

[0018] The term "tank-type water heater" is used in this specification to refer to a heat exchanger in which water is contained in a tank while the water is being heated. One example of a tank-type water heater, illustrated in Fig.1, is a traditional storage-type water heater, having a water tank 220, a dip tube 225, and a flue 230 extending through the water tank 220. Hot gas flows through the flue 230 and heats the water in the tank 220 through the flue wall.

[0019] The term "flow-type water heater" is used in this specification to refer to a heat exchanger in which water is heated as the water flows. One example of a flow-type water heater 120, illustrated in Fig. 1, is a tankless water heater, in which hot gas flows over heat exchange tubes 250 to heat water flowing through the tubes 250. The heat exchange tubes 250 typically include radially-extending or axially-extending fins 260. One example of a well-known, commercially-available and relatively low-cost heat exchanger tube 250 includes a copper tube with aluminum fins. The fins 260 may extend radially (as illustrated in Fig. 1), axially (i.e., along the length of the tube 250), or in another suitable arrangement for the direction of flow of hot gas 135, and other heat transfer considerations. Coatings may be applied to the aluminum finned copper tubing to prevent or slow down corrosion.

[0020] The flow-type water heater 120 may be of the parallel-flow variety (in which the water and hot gas flow in the same direction), the counter-flow variety (in which the water and hot gas flow in opposite directions), the cross-flow variety (in which the water and hot gas flow in neither the same direction nor opposite directions, but cross each other at a non-zero angle), or some combination of these several varieties (in which hot gas flows over various portions of the heat exchange tubes 250 parallel, counter, across, or some combination of these flows with respect to the flow direction of the water in the tubes).

[0021] The term "hot gas" is used in this specification to refer to products of combustion, hot air, or any other hot, gaseous medium. The term "source of hot gas" is used in the specification to refer to a device that produces the hot gas. An example of a source of hot gas 130 is a fuel-fired burner, which may be found in a combustion chamber under the water tank 220 of a traditional tank-type water heater. The fuel burned by a fuel-fired burner may be any suitable and available type of fuel, including, but not limited to, natural gas, propane, fuel oil, coal, wood, or any other type of hydrocarbon or other fuel that can be burned to generate products of combustion. A fuel-fired burner typically burns a combustible mixture of a fuel and air.

[0022] Other examples of sources of hot gas 130 are: a fuel cell or other electrochemical energy conversion device, a heat pump or other refrigerant cycle, and a turbine or micro-turbine engine or other electricity producing device. Air or another medium flowing over the heat producing portion of these devices can be the hot gas used in the present invention. In a residential environment, certain regulations in the United States require that the maximum temperature of the products of combustion of fuel-fired appliances, such as a water heater, not exceed ambient air temperatures by some margin. For example, an applicable ANSI standard requires that the temperature of products of combustion do not exceed ambient air temperatures by more than 480°F. To account for all expected ambient conditions, the temperature of the hot gas in residential applications of the present invention will typically not exceed 600 °F.

[0023] In the water heater 100 illustrated in Fig. 1, the tank-type water heater 110 and the flow-type water heater 120 may together be referred to as a "heat exchanger," with the tank-type water heater 110 being a primary heat exchanger and the flow-type water heater 120 being a secondary heat exchanger. The term "primary heat exchanger" means the portion of the heat exchanger through which the hot gas flows first. The term "secondary heat exchanger" means the portion of the heat exchanger that receives the hot gas 135 from the primary heat exchanger (e.g., hot gas that has already flowed through the primary heat exchanger) and exchanges heat from the hot gas to water in the secondary heat exchanger. In other embodiments, the flow-type water heater 120 may be the primary heat exchanger and the tank-type water heater 110 may be the secondary heat

exchanger.

[0024] The water heater 100 includes a hot gas circuit 280 and a water heating circuit 290. In the hot gas circuit 280, hot gas 135 from the source of hot gas 130 flows under the influence of the blower 140 through the flue 230 in the tank-type water heater 110, through the hot gas connecting conduit 150, through the flow-type water heater 120, and out the hot gas exhaust conduit 190. In all illustrated embodiments, it will be understood that components may be moved to various locations, provided that they meet their functional requirements. For example, the blower 140 may be positioned between the tank-type water heater 110 and the flow-type water heater 120 so that it is drawing hot gas 135 through the tank-type water heater 110 and pushing the hot gas through the flow-type water heater 120.

[0025] With reference to Fig. 1A, in the water heating circuit 290, water flows under the influence of the pump 180 out of the tank 220 by way of the dip tube 225, through the water connecting conduit 160, through the heat exchange tubes 250 in the flow-type water heater 120, through the water return conduit 170, and back to the tank 220. The check valve 165 has a low cracking pressure (e.g., ½ psi) so it easily opens when the pump 180 is running, but it is closed during standby to reduce heat losses and siphoning as water in the flow-type water heater 120 cools. The check valve 165 can be positioned on either side of the flow-type water heater 120, and is shown on the inlet side in Fig. 1A as an example only. The hot gas 135 heats the water in the tank-type water heater 110 through the flue wall, and heats water flowing through the heat exchange tubes 250 in the flow-type water heater 120.

[0026] In one embodiment, the tank-type water heater 110 may be a non-condensing water heater and the flow-type water heater 120 may be a condensing water heater. The term "non-condensing water heater" means a water heater in which the temperature of the hot gas 135 does not fall below the dew point of the hot gas. The term "condensing water heater" means a water heater in which the temperature of the hot gas 135 falls below a dew point of the hot gas 135 to cause condensate to form. The term "condensing water heater" includes fully-condensing water heaters, in which all or substantially all water condenses out of the hot gas 135, and partially-condensing water heaters, in which the temperature of the hot gas drops sufficiently for only a portion of the water to condense out of the hot gas 135.

[0027] In some embodiments, both the tank-type water heater 110 and the flow-type water heater 120 are condensing water heaters, with the tank-type water 110 heater being partially-condensing and the flow-type heater 120 being fully-condensing. Because the flow-type water heater 120 utilizes waste heat from the tank-type water heater 110 to heat water, the flow-type water heater 120 may be called a "recuperator." If a tank-type water heater 110 is used as the secondary heat exchanger, it too may be called a "recuperator;" the term is not limited to only flow-type heat exchangers.

[0028] In the schematic illustration of Fig. 1, the tank-type water heater 110 is a non-condensing water heater and the flow-type water heater 120 is a condensing water heater. Condensate 295 forms in the flow-type water heater 120 and is directed to a suitable receptacle or drain.

[0029] With reference to Fig. 1A, the water heater 100 is also interconnected with a water recirculation circuit 310, which includes the pump 180, the hot water supply pipe 200, the recirculation pipe 210, and a three way zone valve 325. The hot water supply pipe 200 communicates between the tank 220 and a hot water faucet 330 (e.g., at a sink or in a tub or shower) in the building in which the water heater 100 is situated. In one arrangement, the pump 180 may be programmed to energize at a desired time of day (e.g., prior to expected use of the hot water faucet 330). The pump 180 causes water to flow out of the tank 220, through the hot water supply pipe 200, and back to the tank 220 through the recirculation pipe 210, three-way zone valve 325 and water return conduit 170. This moves hot water from the tank 220 into the hot water supply pipe 200, to maintain a ready supply of hot water in the hot water supply pipe 200.

[0030] The three-way zone valve 325 permits water to flow to the return conduit 170 from the water heating circuit 290 or the recirculation circuit 310 under the influence of the pump 180. In view of the foregoing, the present invention utilizes the same pump 180 to move water through the water heating circuit 290 and the water recirculation circuit 310.

[0031] It may also be said that the present invention provides a water heater 100 in which the pump 180 accomplishes a first purpose related to the water heater 100 and is also used for a second purpose that includes circulating water through the hot water supply pipe 200 and back to the water heater 100 to maintain a ready supply of hot water in the hot water supply pipe 200. In the illustrated embodiment, the first purpose of the pump 180 is to move water from the tank-type water heater 110 through the flow-type water heater 120. Another example of a first purpose for the pump 180 is anti-stacking circulation within the tank 220 (which would in essence be the water heating circuit 290 without the flow-type water heater 120).

[0032] In other embodiments, the primary and secondary heat exchangers may be other combinations of tank-type and storage type water heaters 110, 120. For example, the illustrated primary and secondary heat exchanger could be reversed (i.e., the flow-type water heater 120 is the primary heat exchanger and the tank-type water heater 110 is the secondary heat exchanger), or both the primary and secondary heat exchangers are tank-type water heaters 110, or both the primary and secondary heat exchangers are flow-type water heaters 120. In this regard, another aspect of the invention is that the first purpose of the pump 180 is to circulate water through the primary and secondary heat exchangers, regardless

of the type of heat exchanger employed as the primary and secondary heat exchangers.

[0033] The controller 212 controls operation of the source of hot gas 130, blower 140, pump 180, and three-way zone valve 325. The controller 212 opens a gas valve to supply fuel to the burner or source of hot gas 130. While the source of hot gas 130 is operating (e.g., while the burner is creating products of combustion 135), the controller 212 energizes the blower 140 to move the hot gas through the system, and energizes the pump 180 to move water through the flow-type water heater 120. The three-way zone valve 325 is normally open between the flow-type water heater 120 and the tank 220. The controller 212 switches the three-way zone valve 325 during recirculation, to place the recirculation pipe 210 in communication with the tank 220.

[0034] During a hot water draw at the faucet 330, hot water is drawn from the tank 220 and cold water is introduced through the dip tube 225. During a sustained hot water draw, the temperature of the water in the tank 220 may drop below a trigger temperature at which the controller 212 engages the burner 130, blower 140, and pump 180. In such event, the cold water moves through the flow-type water heater 120 before entering the tank 220 through the water return conduit 170. During standby, if water in the tank 220 drops below the trigger temperature, the controller 212 engages the burner 130, blower 140 and pump 180, which causes water in the tank 220 to flow up through the dip tube 225, through the flow-type water heater 120, and back to the tank 220 through the water return conduit 170. The dip tube 225 therefore accommodates two-way water flow in this arrangement.

[0035] Fig. 1B illustrates a variation on the arrangement, in which water moves in counterflow and cross-flow directions with respect to the hot gas 135 in the flow-type water heater 120 (as distinguished from Fig. 1A, in which the water moves in parallel and cross-flow directions). In this arrangement, the water connecting conduit 160 and water return conduit 170 are switched, compared to Fig. 1A, because of the opposite direction of water flow through the flow-type water heater 120. In this arrangement, water flows in only one direction (i.e., down into the tank 220) through the dip tube 225.

[0036] The check valve 165 in this arrangement is in the opposite direction from its configuration in Fig. 1A, such that water can flow from the flow-type water heater 120 to the tank 220 but not in the opposite direction. As in the arrangements of Figs. 1A and 1C, the check valve 165 is sufficiently biased to its closed position to prevent or reduce heat losses and siphoning as a result of cooling water in the heat exchanger tubes 250, but has a low cracking pressure (e.g., ½ psi) to easily open under the influence of the pump 180.

[0037] The three-way zone valve 325 is normally open between the flow-type waer heater 120 and the tank 220, and is switched by the controller 212 for recirculation. During recirculation, the pump 180 displaces all the water (which has typically cooled during standby) in the hot water supply conduit 200, the recirculation conduit 210, the heat exchange tubes 250, and the water supply conduit 160 into the tank.

[0038] The water temperature in the tank 220 can drop below the trigger temperature due to standby heat loss, the recirculation process dumping cooler water into the tank 220, or a sustained hot water draw at the faucet 330. When the water temperature drops below the trigger temperature, the controller 212 energizes the burner 130, blower 140, and pump 180 (the pump 180 may already be operating if the trigger temperature is reached during recirculation). With the burner 130, blower 140, and pump 180 operating, water in the tank is heated by the hot gas 135 through the flue 230 and the water is also moved through the flow-type water heater 120 where it is heated by the condensing hot gas 135. The water is returned to the tank 220 through the water return conduit 170 and dip tube 225.

[0039] Fig. 1C illustrates a variation on the arrangement, with the additional elements of a bypass valve 350 and a two-way valve 360. In this arrangement, water flows through the flow-type water heater 120 in the same direction as in Fig. 1A. The three-way valve 325 is not needed in this arrangement. The check valve 165 is configured the same way as in Fig. 1A.

[0040] The bypass valve 350 may be of the bimetallic, thermostatic variety, or any other suitable variety, and may be set at a desired temperature, which may be, for example, 95°F-105°F for residential purposes. The bypass valve 350 permits water in the hot water supply pipe 200 to be circulated back to the tank 220 through the cold water supply conduit 215, which obviates the need for a dedicated recirculation conduit.

[0041] During recirculation, the controller 212 controls the two-way valve 360 to close communication between the tank 220 and the water connecting conduit 160. Water is moved under the influence of the pump 180 from the hot water supply pipe 200 through the bypass valve 350, through the cold water supply pipe 215, through the water connecting conduit 160, through the heat exchanger tubes 250, and back to the tank 220 through the water return conduit 170.

[0042] In the event of standby heat loss, the controller 212 opens communication between the tank 220 and the water connecting conduit 160 through the two-way valve 360. The controller 212 energizes the burner 130, blower 140, and pump 180 to heat and circulate water through the tank 220 and heat exchange tubes 250. In this event, water flows up through the dip tube 225.

[0043] During a sustained draw, when water temperatures drop below the trigger temperature, the controller 212 energizes the burner 130, blower 140, and pump 180, and opens communication between the the cold water supply pipe 215 and the water connecting conduit 160 through the two-way valve 360. Consequently, incoming cold water flows through the flow-type water heater 120 before reaching the tank 220.

[0044] The invention also provides an method for cost-effectively manufacturing water heaters that have a first efficiency and a second efficiency greater than the fist efficiency. The first efficiency may be referred to as "standard" efficiency, although it may in fact have a very good efficiency. Whatever the efficiency level of the first efficiency, however, the second efficiency is higher than the first efficiency and may be referred to as "high" efficiency.

[0045] On an existing water heater assembly line, a tank-type water heater 110 can be manufactured and assembled, and such tank-type water heater 110 would be a unit having a first efficiency. According to the present invention, any number of water heaters having a second efficiency can be made with certain additional steps and components. The additional steps include attaching a condensing flow-type water heater or recuperator 120 to the tank-type water heater 110 during the assembly process. Thermal efficiencies of about 93% and up to 0.78 EF can be achieved in the water heaters having a second efficiency, manufactured according to the present invention.

[0046] More specifically, if the decision is made to manufacture a water heater 100 of the second efficiency, a recuperator 120, hot gas connecting conduit 150, water connecting conduit 160, and pump 180 are installed on the tank-type water heater 110. The pump 180 is thus enabled to move water from the tank 220, through the recuperator 120, and back to the tank 220, and the flue 230 is in communication with the recuperator 120 to conduct products of combustion from the flue 230 through the recuperator 120.

[0047] If the water heater having the first efficiency is a power vent water heater, then the blower 140 would already be provided on the basic manufacturing line. If the water heater includes a recirculation pump 180 or an anti-stacking pump 180, the pump 180 can be put to the additional purpose of moving water through the water heating circuit 290 that includes the add-on recuperator 120. The flow demands of the pump 180 for the water heating circuit 290 are relatively low, so a pump that is sized for anti-stacking or recirculation can accommodate the second purpose.

[0048] During the manufacturing process for the high-efficiency water heater, the control system of the high efficiency water heater 100 will be modified to enable operation of the pump 180, both during operation of the source of hot gas 130 (e.g., during heating of water in the tank 220) and independent of the source of hot gas 130 (e.g., during recirculation). The pump 180 may operate independent of the source of hot gas 130 during the initial portion of recirculation, as cool and cold water is circulated into the tank 220, but before the water in the tank 220 has dropped to a point that the source of hot gas 130 would be activated. When the source of hot gas 130 is activated, and depending on the plumbing configuration, the control system may switch the three-way valve 325 so that the pump 180 is moving water through the water heating circuit 290. If the plumbing configuration incorporates the recuperator 120 in the recirculation loop 310 (e.g., the three-zone valve 325 upstream of the recuperator 120 and tees the recirculation conduit 210 into the water connecting conduit 160), the recirculation circuit 310 would continue to operate without regard to whether the source of hot gas 130 is operating.

[0049] The invention therefore provides a flexible manufacturing approach, in which an add-on recuperator 120 can be selectively mounted to the water heater or a power vent water heater of first efficiency during assembly. The resulting unit is a condensing water heater having higher efficiency than the first efficiency. As countries raise efficiency standards (e.g., Canada will require all water heaters to be condensing by the year 2015), the present invention will permit complying water heaters to be produced for such countries and countries with lower efficiency standards from the same manufacturing line. The changes can be done with minimal changes in production and investment in tooling.

[0050] The same recuperator 120 can be used on water heaters having wide ranges of sizes, capacities, and thermal inputs, because the exhaust temperature of hot gas from storage type water heaters is within a predictable range with regard to such factors. The use of a single recuperator 120 on multiple size water heaters further improves manufacturing efficiencies.

[0051] Figs. 2 and 3 illustrate two examples of embodiments of the present invention. Like components from Fig. 1 will be give like reference numerals in Figs. 2 and 3.

[0052] The water heater 400 in Fig. 2 is characterized by a recuperator 120 mounted on top of the tank-type water heater 110. The recuperator 120 communicates with the flue 230 of the tank-type water heater 110 by way of the hot gas connecting conduit 150, and also communicates with the hot gas exhaust conduit 190 by way of the blower 140.

[0053] The water heater 400 includes a cold side tee 410 that communicates with the cold water supply pipe 215 (which may also function as the recirculation pipe 210), a large diameter dip tube 430 in the tank 220, and the water connecting conduit 160. Within the cold side tee 410 is a check valve 440 that prevents direct communication between the cold water supply pipe 215 and the large diameter dip tube 430. The check valve 440 causes all water flowing out of the cold water supply pipe 215 and the large diameter dip tube 430 to flow through the water connecting conduit 160 and into the recuperator 120. If a portion of the cold water supply pipe 215 is also used as the recirculation pipe 210, all water returning to the tank 220 via the recirculation loop 310 will flow through the recuperator 120 prior to reaching the tank 220. Also within the cold side tee 410 is a heat trap 450 that reduces heat losses or thermal siphoning through the large diameter dip tube 430. The functionality of the heat trap 450 may be incorporated into the check valve 440 in some embodiments. The cold side tee 410 may include quick connections for ease of installation.

[0054] The water heater 400 also includes a hot side spud 460 having a concentric fitting 470. The tank 220 communicates with the hot water supply pipe 200 through the hot side spud 460, around the outside of the concentric fitting 470. The water return conduit 170 communicates with a small diameter dip tube 480 in the tank 220 through the inside of the concentric fitting 470. The hot side spud 460 may include quick connections for the hot water supply pipe 200, small diameter dip tube 480, and the water return conduit 170.

[0055] The recuperator 120 includes a housing 485, a front dividing wall 490, a rear dividing wall 500 and a plurality of aluminum-finned copper heat exchange tubes 250. The heat exchange tubes 250 communicate in series via elbows and each end. The heat exchange tubes 250 are disposed between the dividing walls 490, 500. The space in front of the front dividing wall 490 defines with the housing 485 an inlet plenum, which receives the hot gas 135 from the hot gas connecting conduit 150. The space to the rear of the rear dividing wall 500 defines with the housing 485 an outlet plenum, which communicates with the blower 140.

[0056] In operation, the blower 140 draws hot gas 135 out of the flue 230, over the front divider wall 490, down around the heat exchange tubes 250, and under the rear divider wall 500, and then blows the hot gas out the exhaust conduit 190. The pump 180 moves water up the large diameter dip tube 430, through the water connecting conduit 160, through the heat exchange tubes 250, and back into the tank 220 through the water return conduit 170 and small diameter dip tube 480. A check valve 510 on the outlet side of the pump 180 reduces thermal siphoning from water in the tank 220 to water in the heat exchange tubes 250 of the recuperator 120. The check valve 510 may have a low cracking pressure (e.g. 0.5 psi). The recuperator 120 is a condensing recuperator, and condensate is drained from the housing into an appropriate receptacle or drain.

[0057] The water heater 600 in Fig. 3 is characterized by a recuperator 120 mounted on a side of the tank-type water heater 110. The recuperator 120 communicates with the flue 230 of the tank-type water heater 110 by way of the hot gas connecting conduit 150, and also communicates with the hot gas exhaust conduit 190 by way of an exhaust duct 605 and the blower 140.

[0058] The water heater 600 includes a cold side tee 610 that communicates with a cold water supply pipe 620 (which may also function as the recirculation pipe 210), a dip tube 630 in the tank 220, and the water connecting conduit 160. The cold side tee 610 may include a heat trap 640 that reduces heat losses or thermal siphoning through the dip tube 630. The cold side tee 610 may include quick connections for ease of installation.

[0059] The water return conduit 170 communicates with the tank through the side of the tank 220. The water return conduit 170 may communicate through an existing fitting in the side of the water tank 220, which would simplify installation of the side-mounted recuperator 120.

[0060] The recuperator 120 includes a plastic heat exchange housing 690 and an aluminum-finned copper heat exchange tube 250. The fins 260 of the heat exchange tube 250 may extend axially, as illustrated.

[0061] In operation, the blower 140 draws hot gas 135 out of the flue 230, into the heat exchange housing 690, down around the heat exchange tube 250, and up through the exhaust duct 605, and then blows the hot gas out the exhaust conduit 190. Condensate 295 is collected and drained from the exhaust duct 605.

[0062] The pump 180 moves water up the dip tube 630, through the water connecting conduit 160, through the heat exchange tube or tubes 250 (i.e., a plurality of tubes 250 may be bundled in the housing 690), and back into the tank 220 through the water return conduit 170. A check valve on the inlet or outlet side of the pump 180 reduces thermal siphoning from water in the tank 220 to water in the heat exchange tube 250 of the recuperator 120. The check valve may have a cracking pressure of 0.5 psi, for example.

[0063] During recirculation, the pump 180 draws water out of the tank 220 through the hot water pipe 200, and the water displaced from the water pipe 200 returns through the recirculation pipe 210, water connecting conduit 160, heat exchange tube 250, and return pipe 170.

[0064] Thus, the invention provides, among other things, a water heater having primary and secondary heat exchanger and a pump to move water between the primary and secondary heat exchangers. The invention also provides a water in which a pump is used for a first purpose within the water heater and also for the purpose of recirculating water within the building. The invention also provides method of manufacturing a water heater, in which a water heater of a first efficiency can be produced on an assembly line, and with the addition of certain steps and components the water heater can meet a second efficiency greater than the first efficiency.

[0065] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0066] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0067] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0068] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to

any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

[0069] Various features and advantages of the invention are set forth in the following claims.

Claims

1. A water heater comprising:

a tank-type water heater having a tank adapted to store water, a flue extending through the tank;
a source of hot gas, the hot gas flowing through the flue to heat water in the tank;
a flow-type water heater receiving the hot gas from the flue and heating water with the hot gas; and
a pump for moving water from the tank, through the flow-type water heater, and back to the tank.

2. The water heater of claim 1, wherein the water heater is adapted for use in a building having a hot water supply pipe communicating directly with the tank; and wherein the pump also circulates water from the tank through the hot water supply pipe and back into the tank to maintain a ready supply of hot water in the hot water supply pipe.

3. The water heater of claim 1, wherein the flow-type water heater is a condensing water heater.

4. The water heater of claim 1, wherein the temperature of the hot gas does not exceed 600 °F.

5. The water heater of claim 1, wherein the hot gas comprises products of combustion.

6. A water heater communicating with a hot water supply pipe, the water heater comprising:

a source of hot gas;
a heat exchanger for transferring heat from the hot gas to water; and
a pump for accomplishing a first purpose related to the water heater;
wherein the pump is also used for a second purpose that includes circulating water through the hot water supply pipe and back to the water heater to maintain a ready supply of hot water in the hot water supply pipe.

7. The water heater of claim 6, wherein the source of hot gas includes a fuel-fired burner; and wherein the hot gas includes products of combustion.

8. The water heater of claim 6, further comprising a tank-type water heater including a tank for holding the water; wherein the heat exchanger includes a flue extending through the tank; and wherein the hot gas flows through the flue to heat the water in the tank.

9. The water heater of claim 8, wherein the heat exchanger further comprises a flow-type water heater through which the hot gas flows and through which the water flows; and wherein the hot gas heats the water in the flow-type water heater.

10. The water heater of claim 9, wherein the flue is a primary heat exchanger through which the hot gas flows first; and wherein the flow-type water heater is a secondary heat exchanger through which the hot gas flows after flowing through the primary heat exchanger.

11. The water heater of claim 9, wherein at least one of the primary and secondary heat exchangers is a condensing water heater.

12. The water heater of claim 9, wherein the first purpose of the pump is to move water from the tank-type water heater through the flow-type water heater.

13. The water heater of claim 6, wherein the heat exchanger includes a primary heat exchanger and a secondary heat exchanger; wherein the primary heat exchanger uses heat from the hot gas to heat the water; and wherein the secondary heat exchanger receives the hot gas from the primary heat exchanger and uses heat from the hot gas to heat the water; and wherein the first purpose of the pump is to circulate water through the primary and secondary heat exchangers.

14. The water heater of claim 13, wherein at least one of the primary and secondary heat exchangers is a condensing heat exchanger.

15. The water heater of claim 13, wherein both of the primary and secondary heat exchangers are condensing heat exchangers.

16. A method for manufacturing a water heater comprising the steps of:

(a) assembling a tank-type water heater having a tank adapted for containing water, a flue extending through the tank, and a fuel-fired burner for creating products of combustion to flow through the flue and heat water in the tank;
(b) deciding whether to manufacture a high efficiency water heater; and
(c) if manufacturing a high efficiency water heat-

er, (i) providing a condensing flow-type water heater; (ii) providing a pump; (iii) plumbing the flow-type water heater and the pump to the tank to enable the pump to move water from the tank, through the flow-type water heater, and back to the tank; and (iv) communicating the flue with the flow-type water heater to conduct products of combustion from the flue through the flow-type water heater to heat water in the flow-type water heater.

17. The method of clam 16, wherein providing a pump includes providing a pump enabled to circulate water from the tank, through a building recirculation system, and back to the tank, in addition to moving water from the tank, through the flow-type water heater, and back to the tank.

18. The method of claim 16, wherein step (c) includes providing a control system that enables operation of the pump during operation of the burner and independent of operation of the burner.

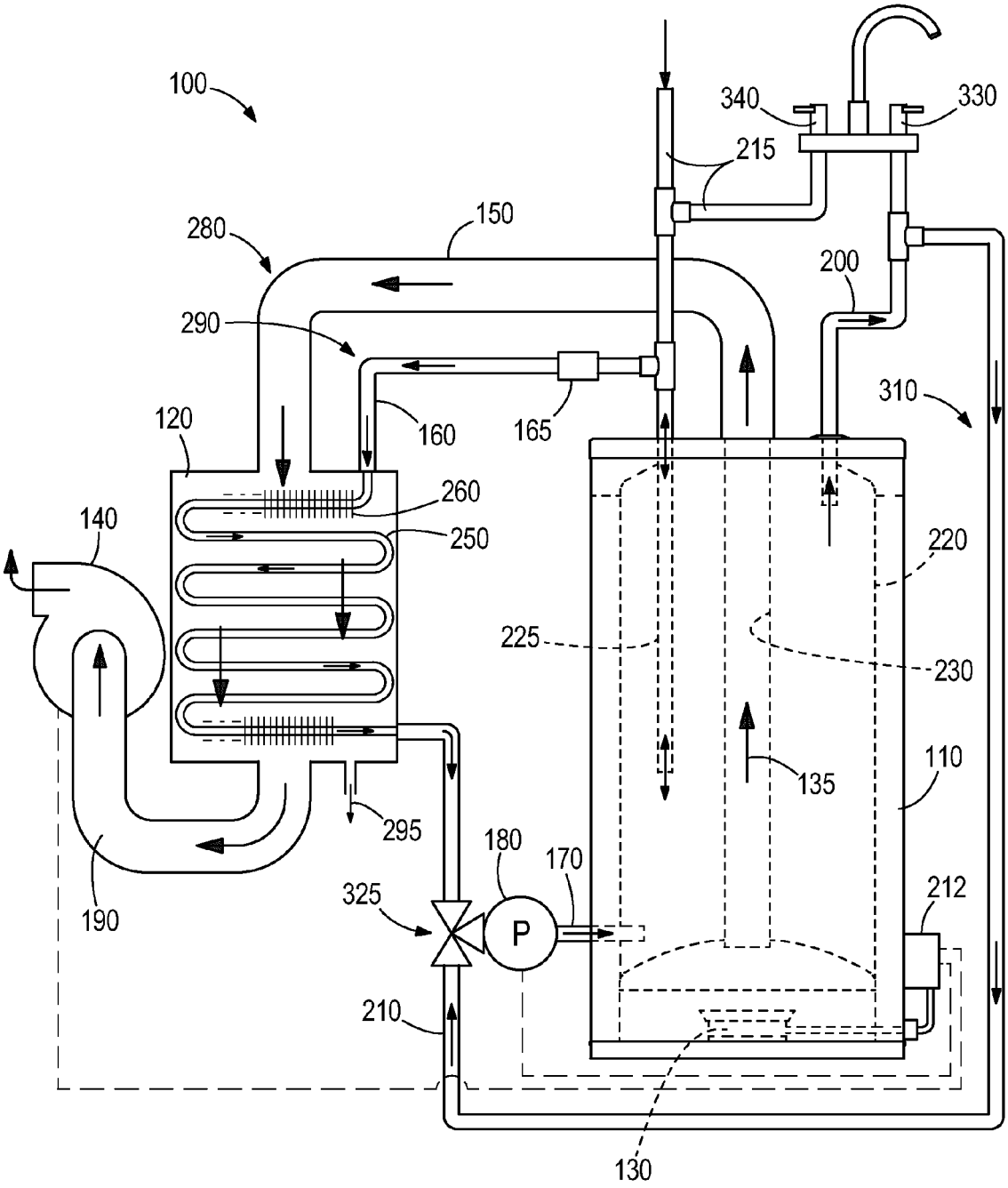
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FIG. 1A

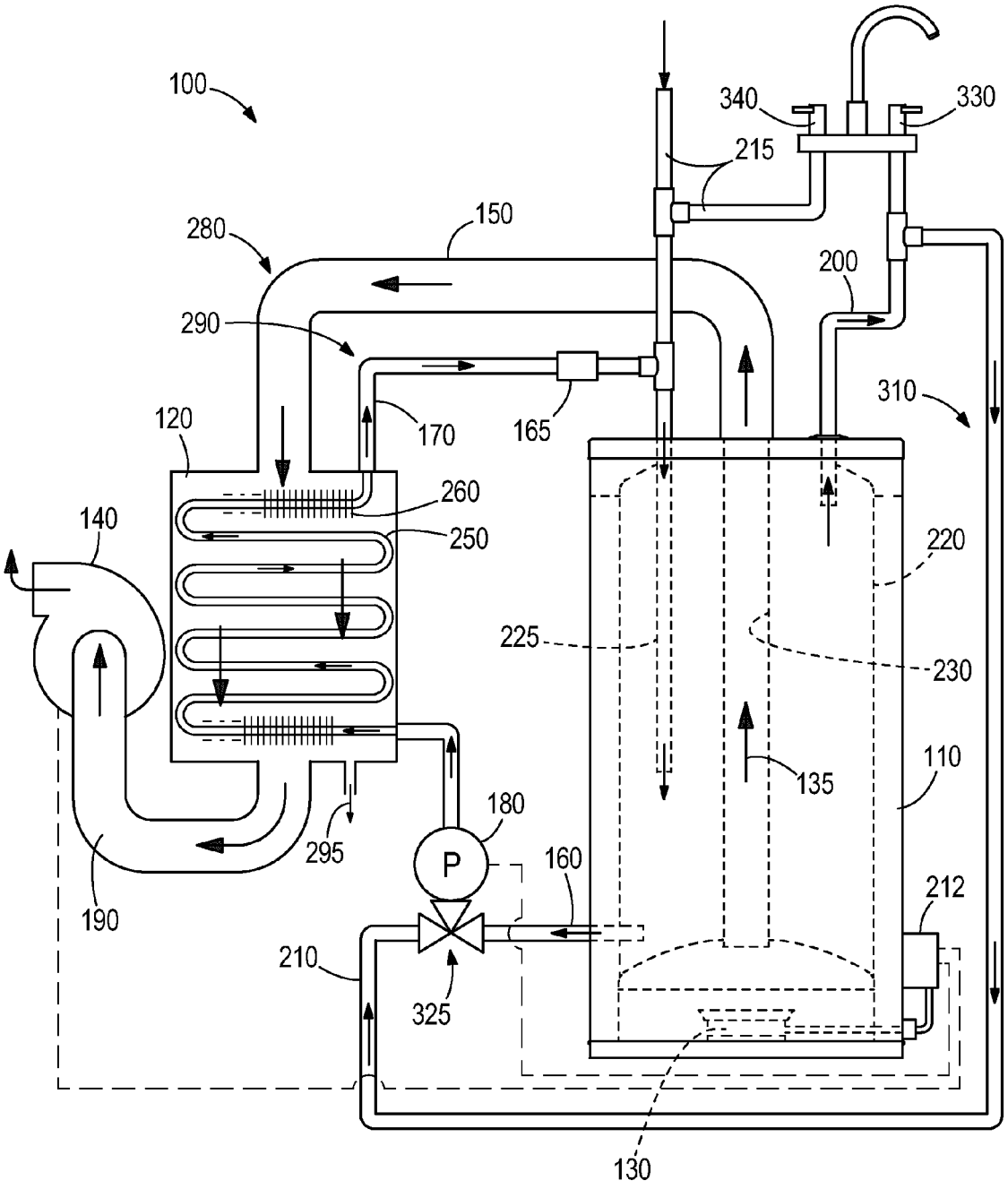
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FIG. 1B

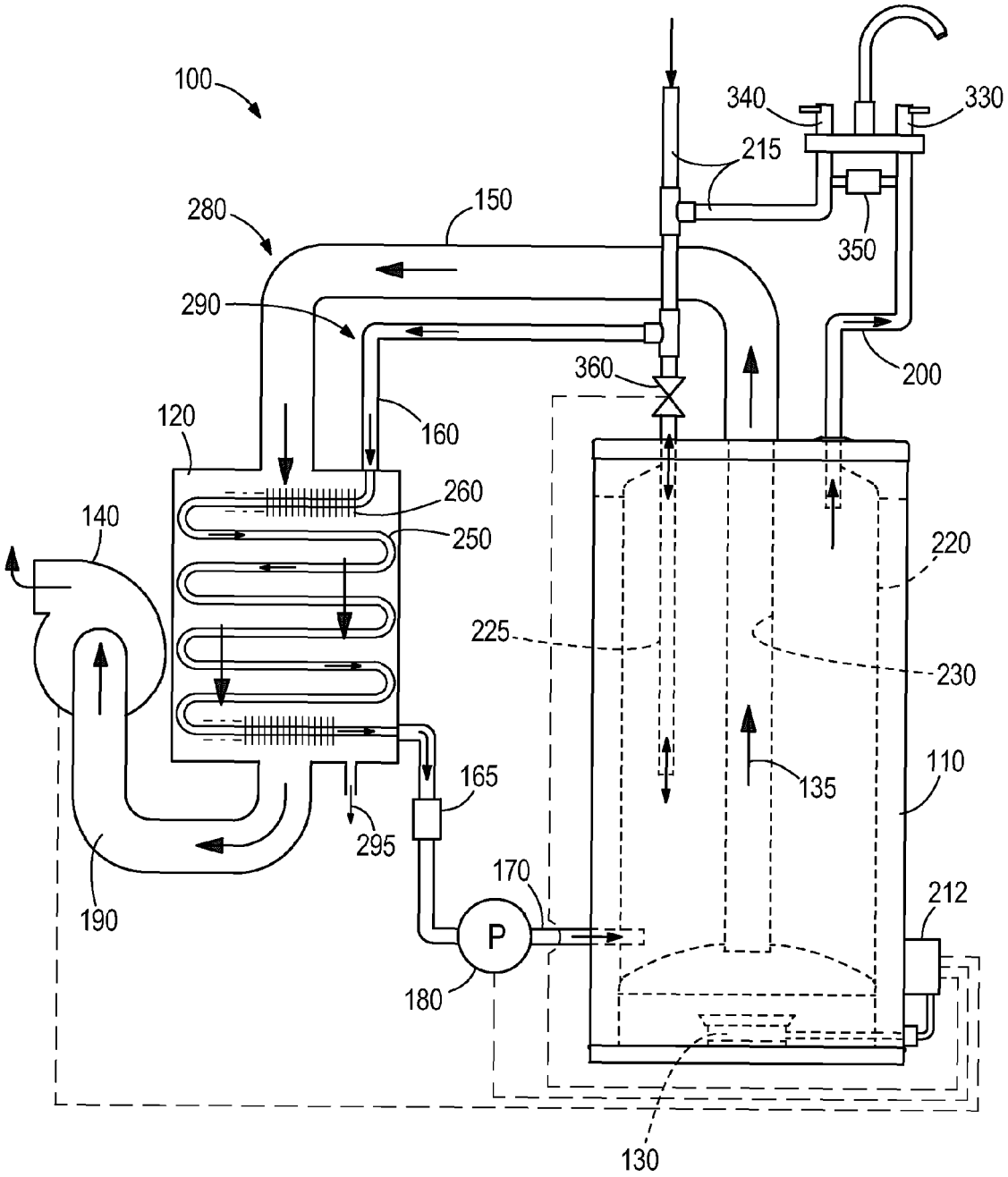
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FIG. 1C

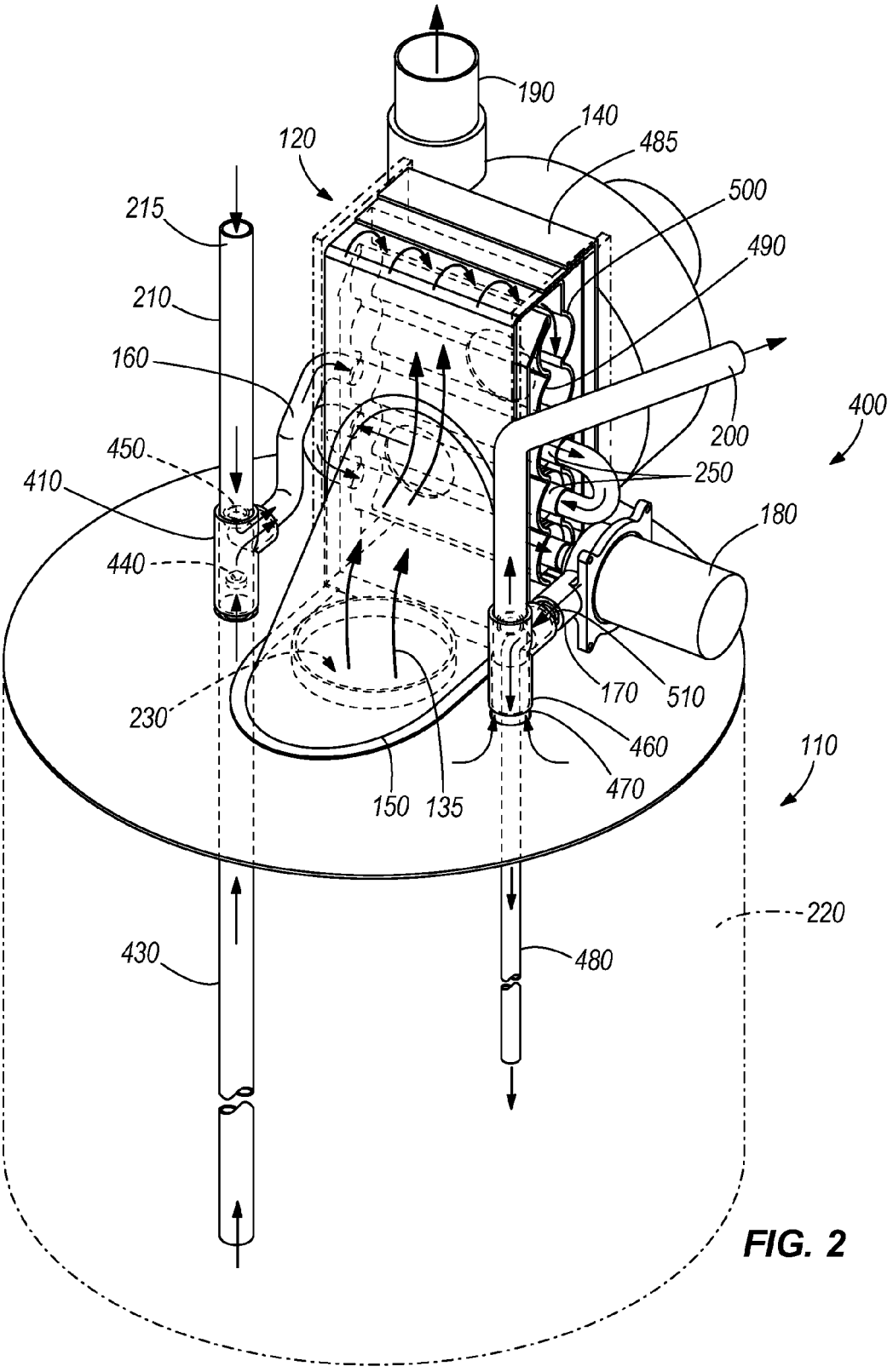
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FIG. 2

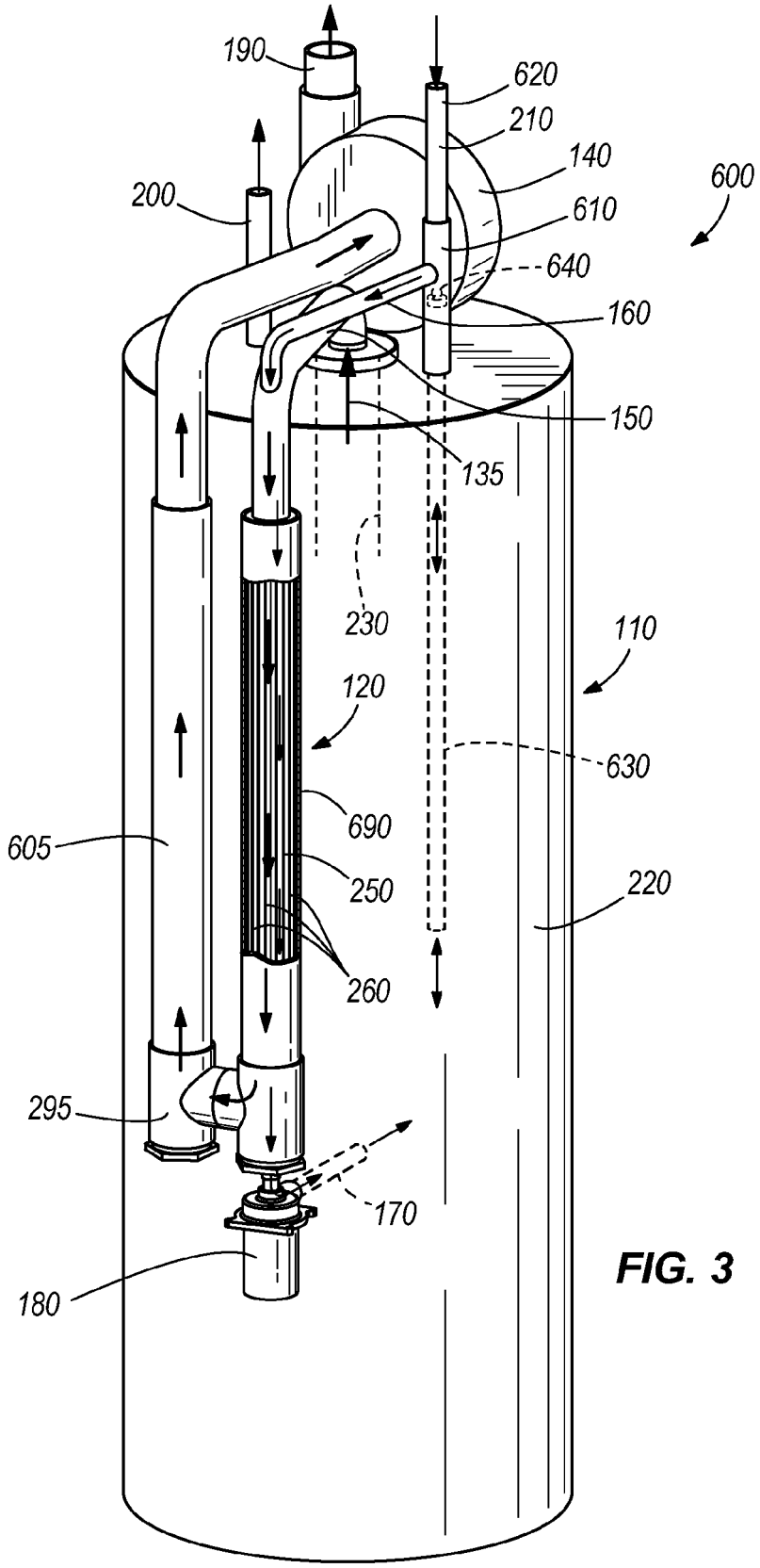
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FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 5738

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 699 872 A1 (BABCOCK OMNICAL GMBH [DE] OMNICAL GMBH [DE]) 6 March 1996 (1996-03-06) * page 2, column 2, line 55 - page 3, column 1, line 16; claim 1; figures 1,2 * -----	1-18	INV. F24H1/12 F24H1/20 F24H9/12
X	DE 22 27 754 A1 (KIRSCHKE GUENTHER) 20 December 1973 (1973-12-20) * page 4, last paragraph; figures 1-3 * * page 7, last paragraph - page 8, line 2 * -----	1-18	
X	DE 34 34 415 A1 (SIEMENS AG [DE]) 27 March 1986 (1986-03-27) * page 8, lines 4-13; figures 1-4 * * page 9, line 25 - page 10, line 7 * -----	1-18	
			TECHNICAL FIELDS SEARCHED (IPC) F24H F24D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 September 2013	Degen, Marcello

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 12 18 5738

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 12 18 5738

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5

A water heater, comprising a tank-type heater having a hot gas passing therethrough, a source of hot gas for heating the water, a flow-type heater receiving the flue gas from the water tank heater, and a pump circulating the water between the two heaters

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2. claims: 6-15

A water heater comprising a hot gas / water heat exchanger and a pump circulating the water through the heater and through the hot water supply pipe and the heater.

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3. claims: 16-18

A method of manufacturing a water heater, comprising the steps of assembling a tank-tape heater, deciding whether to manufacture a high efficiency heater and manufacturing the high efficiency heater

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 18 5738

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-09-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DE 3434415 A1	27-03-1986	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82