A water heater unit is described for providing convective water flow through a water circulatory system. In one embodiment, the water heater unit has an outer housing, a water tank disposed within the housing, and a first cold water inlet coupled to the tank and connectable to a cold water supply line. A hot water outlet is coupled to the tank and connectable to a hot water supply line. A connection chamber adjacent to the tank has a second cold water inlet connectable to the cold water line, and a chamber outlet connected to the first cold water inlet of the tank. The connection chamber has at least one return inlet connectable to the hot water return line at a position to allow a substantially continuous flow of return hot water driven by convection forces without the benefit of a recirculation pump.
Fig. 14
Fig. 15
WATER HEATER WITH PASSIVE AUTOMATIC HOT WATER CIRCULATION THROUGH A HOME OR BUILDING

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to U.S. Provisional Patent Application No. 60/819,687, filed Jul. 9, 2006, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present invention is directed toward water distribution systems, and more particularly to hot water supply and circulatory systems.

BACKGROUND

Conventional water heaters are often positioned in basements or utility/mechanical rooms of homes or office buildings. Typical use of hot water in residential or commercial settings involves non-continuous water flow from a remote water heater to a water outlet assembly (e.g., a faucet, shower, dishwasher, etc.). While hot water flows through the pipes, the pipe wall becomes heated and the hot water is delivered to the water outlet assembly. When flow ceases, water trapped within the piping cools to the ambient temperature. For subsequent water usage, this mass of cool water must be expelled from the piping and the cool pipe must be heated before hot water can arrive at the faucet site.

This delay in hot-water delivery leads to water losses as a user waits for hot water to arrive and watches the once-hot, but now cold, water go down the drain. It may take up to several minutes for a user to receive hot water at a faucet, which can waste large quantities of water, as well as be inconvenient to the user. It is estimated that a typical home wastes more than 10,000 gallons of water a year in this manner; a substantial effect particularly in geographic regions where water is scarce.

Another consequence of cooled water in the hot water supply lines is a negative effect on performance in regard to washing appliances, particularly dishwashers. If the dishwasher operates with water less than the recommended temperature, dissatisfactory results occur.

One conventional approach includes the use of additional heaters that are placed proximate a particular faucet in the home or building. These additional heaters require electricity or gas to keep the water heated at the desired temperature near the faucet, and it may be problematic to maintain a relatively constant temperature of hot water.

Another conventional solution to this problem includes the use of electric pumps that actively pump hot water through the home or building. However, as recognized by the present inventor, such pumps require electricity and maintenance as these pumps are expensive and complicated and can fail over time. Moreover, if the flow rate through the pump is too high, the pump can erode and prematurely degrade water pipes, which can lead to breakages and water damage in the home or building.

Water recirculation valves have been developed to help provide instant hot water at remote faucets through a home or building. Examples of such recirculation valves include those described in U.S. Pat. Nos. 5,331,996; 5,918,625; and 6,161,567, invented by Raymond G. Ziehm, the inventor of the present invention. The valves disclosed in these patents are used in conjunction with hot water return lines that are installed in a home or building, and these valves are generally adapted to be fluidly coupled with a conventional water heater, wherein the valve is positioned externally to the conventional water heater, such as is shown in the figures of these patents. As recognized by the present inventor, such an arrangement of a recirculation valve connected externally to a conventional water heater can consume excessive space, requires additional time for installation due to custom fittings and additional plumbing.

Accordingly, as recognized by the present inventor, what is needed is a water heater that can provide, in operation, passive automatic circulation of hot water through a home or building and thereby provide hot water nearly instantaneously to remote faucets throughout the house or building.

It is against this background that various embodiments of the present invention were developed. The features, utilities and advantages of the various embodiments of the invention will be apparent from the following more particular description of embodiments of the invention as illustrated in the accompanying drawings.

SUMMARY

The present invention provides a water heater unit for a water circulatory system that overcomes drawbacks experienced in the prior art and provides additional benefits. In one embodiment a water heater unit is connectable to a water flow circuit having a hot water supply line, a hot water return line connected to the hot water supply line, and a cold water supply line. The water heater unit has an outer housing, a water tank disposed within the housing, and a first cold water inlet coupled to the tank and connectable to the cold water supply line. A hot water outlet is coupled to the tank and connectable to the hot water supply line.

A connection chamber is provided adjacent to the tank. The connection chamber has a second cold water inlet connectable to the cold water line, and a chamber outlet connected to the first cold water inlet of the tank. The connection chamber has at least one return inlet connectable to the hot water return line to allow a substantially continuous flow of return hot water driven by convection forces without the benefit of a recirculation pump. A valve is connectable to the return inlet and is moveable between open and closed positions. The valve in the open position allows recirculated hot water to flow into the chamber from the return line for return into the tank, and the valve in the closed position blocks water from flowing from the chamber through the return line to an open, remote water assembly that is calling for water.

In another embodiment, a pumpless hot water recirculation kit is provided for installation in a dwelling having a water flow circuit with a hot water supply line and a cold water supply line. The hot water supply line is connected to a water outlet assembly, and at least one hot water return line is connectable to the hot water supply line adjacent to the water outlet assembly. The pumpless hot water recirculation kit has a water heater remote from the water outlet assembly. The water heater has a housing and a tank disposed within the housing. A first cold water inlet is coupled to the tank and is connectable to the cold water
supply line. A hot water outlet is coupled to the tank and is connectable to the hot water supply line.

[0014] A recirculation device is provided adjacent to the tank. The recirculation device has an interior chamber, a second cold water inlet coupled to the chamber connectable to the cold water supply line, and a chamber outlet connected to the first cold water inlet of the tank. A return inlet is connectable to the hot water return line to allow a substantially continuous flow of return hot water driven by convection forces without the benefit of a recirculation pump. The connection chamber is accessible to connect to the cold water line and the hot water return line at or through the housing.

[0015] In another embodiment, a pumpless water recirculation assembly is provided for convective recirculation of water through a water circuit to a water heater. The water heater has a cold water inlet and a hot water outlet. The water circuit has a hot water supply line, a cold water supply line, and a hot water recirculation line connected to the hot water supply line. The water recirculation assembly has a body having an interior chamber and an outlet portion coupled to the interior chamber. The outlet portion is threadably connectable to the cold water inlet of the tank. A first inlet portion is coupled to the chamber and sealably connectable to the cold water line.

[0016] A plurality of hot water return inlets are coupled to the chamber and sealably connectable to the recirculation line such that at least a segment of the recirculation line is disposed vertically above the water heater. Each hot water return inlet has a flow control valve therein configured to allow hot water to flow in one direction from the recirculation line into the chamber and to block water flow in a reverse direction from the chamber through the hot water return inlet. A cover member is connectable to the tank to define an interior area and configured to contain at least a portion of the body within the interior area. The cover has a first opening in alignment with the first inlet and a second opening in alignment with the hot water inlet. The water recirculation assembly is installable in the water circuit to provide a substantially continuous flow of return hot water driven by convection forces in the water circuit without the benefit of a recirculation pump.

[0017] In another embodiment, a continuous hot water supply system is connectable to a water supply line and to a flow circuit. The flow circuit has a hot water supply line and a hot water return line connected to the hot water supply line. The continuous hot water supply system has a water heating assembly coupled to the water supply line, wherein at least a portion of the water supply line extends from the water heating assembly. A reservoir is remote from the water heating assembly and is positioned to receive heated water from the water heating assembly. The reservoir has a first inlet and a first outlet, wherein the first outlet is connectable to the hot water supply line. A circulation device is in fluid communication with the reservoir.

[0018] The circulation device has a second inlet connectable to the water supply line to receive water therefrom. The circulation device has a second outlet in fluid connection with at least one of the water heating assembly and the reservoir. The circulation device has at least one return inlet connectable to the hot water return line and configured to allow a substantially continuous flow of return hot water therethrough driven by convection forces without the benefit of a recirculation pump. A valve is connectable to the return inlet and is movable between open and closed positions. The valve in the open position allows recirculated hot water to flow into the chamber from the return line, and the valve in the closed position blocking water from flowing from the chamber through the return line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is a schematic view of a water flow circuit with a water heater in accordance with an embodiment of the present invention.

[0020] FIG. 2 illustrates an example of a water heater having automatic recirculation in accordance with one embodiment of the present invention.

[0021] FIG. 3 illustrates a portion of a sectional view of the example water heater of FIG. 2 in accordance with one embodiment of the present invention.

[0022] FIG. 4 illustrates an example of a check valve that may be used in a water heater in accordance with one embodiment of the present invention.

[0023] FIG. 5 illustrates an example of a faucet, return line, and water heater coupled together in accordance with one embodiment of the present invention.

[0024] FIG. 6 illustrates an example of a circulation device attached to a conventional water heater in accordance with one embodiment of the present invention.

[0025] FIG. 7 illustrates an example of a circulation device in accordance with one embodiment of the present invention.

[0026] FIG. 8 is an isometric view of a circulation device in accordance with another embodiment of the present invention.

[0027] FIG. 9 is an enlarged cross-sectional view of the circulation device taken substantially along line 9-9 of FIG. 8.

[0028] FIG. 10 is a front elevation view of a circulation device in accordance with yet another embodiment of the present invention.

[0029] FIG. 11 is a front elevation view of a water heater unit with a side-mounted circulation device in accordance with yet another embodiment of the present invention.

[0030] FIG. 12 is an enlarged front elevation view of the side-mounted circulation device of FIG. 11.

[0031] FIG. 13 illustrates an example of a shell for attachment to a conventional water heater, the shell for enclosing a circulation device, in accordance with one embodiment of the present invention.

[0032] FIG. 14 illustrates a fluid circuit with a tankless water heater and a circulation device in accordance with another embodiment of the present invention.

[0033] FIG. 15 illustrates a fluid circuit with a tankless water heater and a circulation device in accordance with yet another embodiment of the present invention.

DETAILED DESCRIPTION

[0034] Embodiments of the present invention relate to a water flow circuit and components thereof having a capability or feature of providing instant or substantially instant delivery of hot water to faucets, including remote faucets, located throughout a home or building, without the need for water recirculation pumps or localized extra water heaters positioned near faucets of the home or building.

[0035] In one example, a water heater is provided with a circulation device integral within the water heater assembly.
The water heater thereby automatically circulates hot water through the home or building while the hot water faucets are closed. When a user (i.e., a person or machine) needs hot water and opens a hot water faucet or valve, hot water is instantly available at the faucet because the water heater was automatically circulating hot water through the water flow circuit of a home or building while the faucets were closed. One or more convective circulation loops are established from the water heater outlet to the remote faucets and back to the heater through return lines in the water heater that contain valves so as to prevent reverse flow and to ensure reliable operation on a small pressure differential.

In one embodiment, the water heater may have the circulation device positioned inside the top surface of the water heater. Insulating material may be added around or about the body of the circulation device within the housing of the water heater. This configuration will normally be assembled in this fashion during the manufacturing process.

In another embodiment, a circulation device may be provided as a part of a kit that may be added externally to a conventional water flow circuit and/or water heater so as to add the instant hot water functionality to a conventional water flow circuit and/or water heater in a compact fashion. Various embodiments of the present invention are described herein.

FIG. 1 is a schematic view of a water flow circuit 1 with a water heater 10 in accordance with one embodiment of the present invention. The water flow circuit 1 includes the water heater 10 coupled to a plurality of water outlet assemblies 3 by a plurality of water lines 4. In the illustrated embodiment, the water outlet assemblies 3 can be faucets or other controllable water outlet devices. The water heater 10 has a pumpless circulation device 6 connected to the water lines 4 so as to provide a continuous flow of hot water past the water outlet assemblies 3 via convection forces, thereby providing instant hot water at any time to the water outlet assembly.

In the illustrated embodiment, the water lines 4 include a cold water supply line 16 connected to the circulation device 6 so as to provide water to the water heater 10. A hot water supply line 19 is connected to the water heater 10 and to one or more of the water outlet assemblies 3, and hot water return lines 22 are connected to the hot water supply line 19 adjacent to the water outlet assemblies 3. The hot water return lines 22 are also connected to the pumpless circulation device 6. As discussed in greater detail below, the circulation device 6 is configured with the water lines 4 to provide the continuous hot water flow through the water flow circuit 1 without requiring a recirculation pump to generate the water flow.

FIGS. 2-3 illustrate an example of a water heater 10 having the pumpless circulation device 6 for automatically circulating hot water through a home or building in accordance with one embodiment of the present invention. In one example, the water heater 10 has a tank 12, a cold water inlet 14 for receiving water from the cold water supply line 16, and a hot water outlet 18 (FIG. 2) for delivering hot water to the home or building through the hot water supply lines 19 (FIG. 2). The water heater 10 also includes one or more return inlets 20 adapted to be coupled with the one or more hot water return lines 22 that are provided in the water flow circuit in a home or building.

The return inlets 20 are in fluid communication with the hot water supply lines 19 at one end and with the cold water inlet 14 of the water heater 10 at the other end. The pumpless circulation device 6 includes a chamber 24 configured to accommodate the hot water return inlets 20 and the cold water inlet 14 and to interface with the heater tank 12. Water in the chamber 24 enters the water heater tank 12.

The chamber 24 can take any form desired. The chamber 24 provides a fluid entry point for fluid from the return inlets 20 and the cold water inlet 14. The chamber 24 may be provided as an input port to fluidly couple the return lines 22 with the cold water inlet 14 or water heater tank 12. In this example, the chamber 24 establishes a transverse orientation of the return lines 22 relative to the cold water inlet 14. In another embodiment, the chamber 24 can establish an angled orientation or a parallel orientation between the return lines 22 and the cold water inlet 14. In one example, the chamber 24 may be formed from plastic, chlorinated PVC plastic, metal, brass, or any other conventional material.

The return inlets 20 must be provided with check valves 30 (FIG. 3) or other conventional valves that permit water flow into the water heater 10 through the return inlets 20 but prevent water flow in the opposite direction. For instance, FIG. 4 illustrates an example of a check valve 30 having a moveable poppet 32 in a passageway 34. The poppet 32 has a specific gravity at or near 1.0 (the specific gravity of water) to provide the sensitivity to reliably open when in the convective mode. The poppet 32 has a body 36 whose cross section will allow water to flow through the passageway 34 when in the open position, terminating at one end with a nose 38 that interfaces with a valve seat 40 to terminate flow. An opposing end 42 of the poppet 32 may be flat.

In this example, the check valve 30 includes a cylindrical passageway 34 adapted to receive a square poppet 32 and provide limited lateral movement of the poppet within the passageway. The passageway 34 may be provided at a first end with a fluid opening 46 into the chamber 24 of the water heater 10. At this first end, the passageway 34 may be provided with a ridge or shoulder 44 to limit the travel of the poppet 32. On the opposing second end of the check valve 30, the passageway 34 may be terminated by a valve seat 40 defining a fluid opening, the seat adapted to mate with the end of the poppet 32 when the poppet is in the closed position within the check valve 30. When the poppet 32 is in the closed position, water is prevented from flowing in the opposing direction. In the illustrated embodiment, the check valve 30 moves automatically in response to the differences in water pressure, such that the check valve is not adjustable. In other embodiments, the chamber 24 can include one or more adjustable valve assemblies in the return inlets 20. The adjustable valve assemblies can be manually adjustable, automatically adjustable, or both to help control the water flow rate through the chamber.

In one embodiment, the chamber 24 includes a filter 35 (shown schematically in FIG. 3) in each return inlet 20 just upstream from the check valve 30. The filters 35 allow the water to flow therethrough without negatively impacting the flow rate. The filters 35, however, are positioned and sized to capture any solid impurities, such as sand, dirt, rust particles, or other solids, that may be flowing
through the return lines 22 and that may clog or jam the check valves 30. The filters 35 can be made of a screen or mesh material, or other suitable filtering material or materials. In one embodiment, the chamber 24 is configured so the filters 35 are easily removable for cleaning or replacement.

[0046] If desired, the water heater 10 (FIG. 2) may be sized and shaped in a manner similar to the general shape of water heaters, such as generally cylindrical with a flat top surface 48, and insulating material may be placed around and above the heater tank 12, although other shapes could be used if desired. The water heater 10 of the illustrated embodiment has the chamber 24 and the water inlet 14 adjacent to the top of the tank 12, although other embodiments can have the chamber and water inlet adjacent to the side or bottom portion of the tank. As shown in FIG. 3, the water heater 10 has an outer shell 52 that preferably encloses the tank 12, portions of the return lines 22, the chamber 24, and the check valves 30, in one example. The outer shell 52 is provided with an opening for the cold water inlet 14 as well as openings for the return inlets 20. Insulation 50 may be provided about the chamber 24 and the return inlets 20.

[0047] In operation, the water heater 10 provides for natural and constant convective flow of water through a closed fluid circuit 56 (FIG. 5) formed by the chamber 24, hot water tank 12, hot water supply lines 19, and return lines 22. The convective flow will be described with respect to the system of FIG. 5 having one hot water supply line 19, one faucet 54 and one return line 22, although it is understood that the same principles apply if more than one of these elements is used.

[0048] In particular, the fluid circuit 56 is formed through the fluid connections between the following: the water heater tank 12; the hot water outlet 18 of the water heater 10 being fluidly coupled with the hot water supply line 19; the hot water supply line fluidly coupled with one or more faucets 54; the return line 22 fluidly coupled with the hot water supply line proximate one of the faucets, preferably the farthest from the heater on any hot water branch; the return line also being fluidly coupled with the chamber 24 of the water heater 10, the chamber 24 being fluidly coupled with the cold water inlet 14 to the tank 12, thereby closing the fluid circuit 56.

[0049] The chamber 24 is also coupled with the cold water supply line 16, although for purposes of describing the convective fluid flow, the cold water supply line is not part of the circuit during convective fluid flow.

[0050] Convective fluid flow occurs constantly without the need for pumps or additional localized water heaters in the fluid circuit 56 by virtue of the water heater 10 of the present invention. During normal operation, a user opens the faucet 54, and that open faucet allows water from the water heater 10 to exit the hot water outlet of the water heater and travel through the hot water supply line 19 up to and out of the faucet. While the faucet 54 is open, cold water from the cold water supply line 16 enters the chamber 24 and travels into the heater tank 12 to replace the volume of water exiting the faucet. When the faucet 54 is open, the check valve 30 in the return inlet 20 closes, due to the low pressure in the hot water supply line 19, to prevent water from the cold water supply line 16 flowing through the return lines 22 to the faucet.

[0051] Once the faucet 54 is closed, the check valve 30 in the return inlet 20 opens due to convective pressure, permitting convective fluid flow from the return line 22, into the chamber 24, and back into the tank 12. Fluid will circulate through the fluid circuit 56 (including through the water heater 10) constantly while the faucet is closed. Because cold water is denser than hot water, and because pressure is proportional to density, the temperature differences of water within the fluid circuit 56 will create pressure differences within the circuit, and the pressure differences will induce fluid flow via convection through the fluid circuit. As the distance from the water heater 10 increases, the water in the circuit will be cooler due to ambient temperatures cooling the water over time. Hence, the natural convective flow of water through the fluid circuit 56 will cause the cooler water in the return line 22 to constantly return towards the water heater 10 without requiring the aid of a pump or other mechanical assist device. Hence, in accordance with embodiments of the present invention, the water heater 10 automatically circulates hot water towards the faucets 54 and through the return line 22 back through the fluid circuit to the chamber 24 in a home or building while the faucets are closed.

[0052] In another embodiment of the present invention and as shown in FIGS. 5-6, a circulation device 60 may be attached to a water heater assembly 61 (FIG. 6), and a cap 64 may be attached to the top of the water heater assembly over the circulation device. In one embodiment, the circulation device 60 and the cap 64 can be sold along with or for use with a water heater assembly 61, so that the water heater assembly can provide automatic hot water circulation.

[0053] In one example, a circulation device 60 can be provided as shown in the example of FIG. 7. In this example, the circulation device 60 has a main body 62 that is generally rectangular or square in shape with planar top and bottom surfaces 66 and 67 and an arcuate or curved side 68 to match a curved perimeter of the water heater assembly 61. In another example shown in FIGS. 8 and 9, the main body 62 has a short, cylindrical puck shape. The top surface 66 has an inlet 70 for cold water which may be provided as a round or tubular stub 72 extending upwardly from the top surface of the circulation device 60. A standard compression coupling or fitting 74 may be placed about the stub so that a standard copper or PEX pipe can be coupled with the stub 72 and secured to the stub so as to provide a water tight fluid coupling between the cold water supply and inlet stub.

[0054] The circulation device 60 may also be provided with an outlet stub 76 or tube extending outwardly and downwardly from the bottom surface 67 of the circulation device. In one example, the outlet stub 76 may be generally cylindrical with a threaded outer surface adapted to mate with a standard water heater inlet connection, such as using standard ½ inch threaded fittings. In another embodiment, a compression fitting 78 can be connected to the outlet stub 76, and the compression fitting can have a threaded outer surface 79 adapted to mate with the standard water heater inlet connection.

[0055] One or more water return inlet members 80 may extend outwardly from the curved side 68 of the circulation device 60. In one example, three return inlet members 80 are provided along the curved side 68 of the circulation device 60. Each return inlet member 80 has a check valve 30 integrated therewith that permits water flow from a return line 84 (external to the circulation device) into the circulation device 60 through the return inlet members 80 and through the check valve 30, but does not permit water flow
in the opposing direction (i.e., from within the circulation device out through the return inlet members). A standard compression coupling or fitting 81 may be placed about the return inlet member 80 so that a standard copper pipe or PEX tubing can be coupled with the member and secured to the member so as to provide a watertight fluid coupling between the pipe carrying recirculated hot water and the return inlet member.

In one embodiment, the circulation device 60 can include one or more quick-release, water-tight fittings that allow the circulation device to be quickly and easily connected to the associated water lines. For example, the inlet stub 72, the outlet stub 76, and/or the return inlet members 80 can include quick release fittings that releasably, yet sealably, engage the cold water supply line 16, the water heater inlet 14, and/or the return lines 22, respectively. Accordingly, a user can quickly install the circulation device 60, such as in a retrofit process. The quick-release fittings also allow the user to temporarily remove and reinstall the circulation device 60, such as to clean or inspect the device.

FIG. 10 is a front elevation view of a circulation device 100 in accordance with yet another embodiment of the present invention. In this embodiment, the circulation device 100 has a main body 102 that has a cylindrical, generally barrel shape with top and bottom surfaces 104 and 106 and an arcurate sidewall 108. The circulation device 100 has a plurality of hot water return inlets 110 projecting from the top surface and in fluid communication with an interior chamber 112 within the body 100. Each return inlet 110 is connectable to a respective hot water return line 22. The circulation device 100 also has a cold water inlet 114 projecting from the sidewall on one side 116 of the body, and an outlet 118 projecting from the sidewall on the other side 117 of the body. The cold water inlet 114 is connectable to the cold water supply line 16 and is in fluid communication with the interior chamber 112. The outlet 118 is also in fluid communication with the interior chamber 112 and is configured to direct a flow of water from the interior chamber via the cold water inlet 114 and/or the return inlets 110 into the tank 12 (not shown).

FIG. 11 is a front elevation view of a water heater unit 120 with a side-mounted circulation device 122 mounted on the side of a water heater 124 toward the bottom portion of the water heater as to bring water heaters are not designed with cold water inlets in this location. In this embodiment, a cold water inlet 126 of the water heater 124 is provided at the bottom portion of the water heater’s tank 128. The circulation device 122 is connected to the water heater 124 adjacent to the cold water inlet 126 and further connected to hot water return lines 22.

FIG. 12 is an enlarged front elevation view of the side-mounted circulation device 122 of FIG. 11. In this embodiment, the circulation device 122 has a main body 130 that has a cylindrical, generally barrel shape with top and bottom surfaces 132 and 134 and an arcurate sidewall 136. The circulation device 122 has three hot water return inlets 138 radially spaced about the main body 130 and projecting outwardly from the sidewall 136. The return inlets 138 are in fluid communication with an interior chamber 140 within the body 130. Each return inlet 138 is connectable to a respective hot water return line 22, as discussed above.

The circulation device 122 also has a cold water inlet 142 projecting from the top of a return inlets 138. The cold water inlet 142 in other embodiments can be positioned at a different location on the main body 130 relative to the sidewall 136 and the return inlets 138. The cold water inlet 142 is connectable to the cold water supply line 16 and is in fluid communication with the interior chamber 140. The circulation device 122 also has an outlet 144 projecting from the sidewall 136 in axial alignment with one of the return inlets 138. The outlet 144 connects to the inlet of the water tank 128 (not shown).

The return inlet members 80 are adapted to be fluidly coupled with the return line plumbing provided throughout the home or building. Although a particular shape of circulation device 60 has been illustrated and described herein, the circulation device 60 could take other shapes depending upon the particular implementation, for instance in connection with systems as shown and described in U.S. Pat. Nos. 5,331,996, 5,918,625, and 6,161,567, the disclosures of which are hereby incorporated by reference herein in the entirety.

In one example, the return inlet members 80 are generally cylindrical or tubular and can be sized to match the dimensions of the plumbing that they are adapted to be coupled with, for instance ½-inch copper pipe or ½-inch PEX tubing. In one example, the circulation device 60 may be formed from plastic, chlorinated PVC plastic, metal, brass, or any other conventional material. The circulation device may be formed by any conventional process, including stamping, injection molding, sheet metal formation, or any other known process for forming a fluid device.

FIG. 13 illustrates an example of a shell or cap 64 that can be used to enclose the region about the top of a water heater 10 having a circulation device 60 attached thereto. The cap 64 is adapted to be attached to the top of a conventional water heater 10. In one example, the shell is generally cylindrical with a solid top, curved sides, and a hollow interior so that the shell forms an extended cylindrical cap which may be placed over the top surface of the water heater 10. The cap 64 may have an opening 90 along its top surface 92, such as a round opening, which permits the cold water inlet stub 72 of the circulation device to upwardly protrude therefrom. Along a curved side 94 of the cap 64, a set of openings 96 may be provided to permit the return inlet members 80 of the circulation device 60 to outwardly extend therefrom, in one example. The shape of the cap 64 and the positioning and number of the openings will vary depending upon the implementation. For instance, if a circulation device 60 is provided that orientates the cold water inlet stub 72 and the return inlet members 80 in an upward orientation relative to the top of the water heater 10, then the openings 90 and 96 in the cap 64 for the return lines 22 (not shown) may be positioned along the top surface 92 of the cap and not along the side of the cap.

Insulating material 50, such as fiberglass insulation or any conventional insulation, may be provided about or around the circulation device 60 and the top surface 92 of the cap 64, and can be encased within the shell attached to the top of the water heater.

FIG. 14 illustrates a fluid circuit 200 with a tankless water heater 202 and a circulation device 204 in accordance with another embodiment of the present invention. The tankless water heater 202 is a conventional unit that receives and “instantly” heats a flow of cold water from the cold water supply line 16. Although the tankless water heater 202 can heat water very quickly, the conventional tankless water heater systems can experience a delay in providing hot water
to the faucet 206 due to cooled water in the hot water supply pipes as discussed above. The fluid circuit 200 of the present embodiment that includes the tankless water heater 202 avoids the hot water delay so a user will not experience the wait for hot water.

[0066] In the illustrated embodiment, the tankless water heater 202 is connected at an inlet to the cold water supply line 16, and is connected at its outlet to a hot water line 208 that carries heated water away from the tankless water heater. The hot water line 208 provides the heated water to a small reservoir 210 through an inlet portion 212. The reservoir 210 is configured to hold a small volume of water (e.g., 1-5 gallons), although larger or smaller reservoirs can be used in other embodiments. The illustrated reservoir 210 includes a heating element 214, such as a gas or electric heater, configured to maintain the water temperature within the reservoir within a selected range. The reservoir functions in a manner similar to a traditional water heater.

[0067] The reservoir 210 provides hot water to a supply line 218, which in turn provides the hot water to one or more faucets 206. One or more return lines 220 are connected to the hot water supply line 218 adjacent to the faucet(s) 206. Each return line 220 is also connected to a return inlet 222 of a circulation device 204 positioned adjacent to the reservoir 210. The circulation device 204 of the illustrated embodiment has an inlet 226 connected to the hot water line 208, an outlet 228 connected to the inlet portion 212 of the reservoir 210, and one or more return inlets 222 connected to the return lines 220. Each return inlet 222 contains a check valve 230 that operates in substantially the same manner as the check valve 30 discussed above. The circulation device 204 can also include adjustable valves, filters, compression fittings, quick release connectors, and/or other features discussed above in connection with the other embodiments. In another embodiment, the circulation device 204 could be located adjacent to the tankless water heater 202 and inlet 226 is connected to the cold water supply line 16 with the outlet 228 connected to the tankless water heater inlet 201. Alternatively, circulation device 204 could be located adjacent to the tankless water heater 202 via an inlet 226 connected to the hot water outlet 203 of the tankless water heater 202 and outlet 228 connected to the hot water line 208.

[0068] In operation, the tankless water heater 202 heats a flow of water from the cold water supply line 16 and directs the heated water to the small reservoir 210. The heated water continuously flows through the fluid circuit under the convection forces discussed above. Accordingly, the hot water flows from the small reservoir 210, through the supply lines, past the closed faucet(s) 206, through the return line 220, into the circulation device 204 and back into the small reservoir. As the small reservoir 210 has a heating element, the convection currents are maintained and the convection flow is continuous regardless of how long the faucet(s) 206 are closed. When a faucet 206 is open to instantly draw the hot water drawn, the tankless water heater is automatically activated to provide additional heated water into the fluid circuit 200. Accordingly, the fluid circuit 200 with the tankless water heater 202 and the circulation device 204 provides the instant hot water to the faucet(s) 16 and any other hot water outlets in a home or building at all times without the delay suffered by the prior art.

[0069] FIG. 15 illustrates a fluid circuit 200 with a tankless water heater 202 and a circulation device 204 in accordance with another embodiment of the present invention. The fluid circuit 200 is similar to the circuit described above in connection with FIG. 14, such that only the primary differences are discussed. In the illustrated embodiment, the small water reservoir 210 does not include a heating element. Instead, a return loop is 250 is formed by a water line connected at one end 252 to the hot water supply line 218 and connected at the other end 254 to the cold water supply line 16 just upstream of the tankless water heater 202.

[0070] The return loop 250 is configured to provide a flow of water from reservoir back into the cold water supply line for re-entry into the tankless water heater 202 to be reheated. In the illustrated embodiment, a thermostatically-controlled pump 256 is coupled to the reservoir 210 and is connected to the return loop 250. When the water temperature in the reservoir drops below a selected temperature, the thermostatically-controlled pump is activated to move the cooled water from the reservoir back to the tankless water heater 202 through the return loop. The thermostatically-controlled pump 256 is configured to create a sufficient pressure drop or other selected condition to simultaneously activate the tankless water heater 202. When the water temperature in the reservoir rises to a selected temperature, the thermostatically controlled pump shuts off and the tankless water heater also shuts off.

[0071] It is noted that the thermostatically-controlled pump 256 does not drive the water flow through the fluid circuit 200. Instead, the continuous hot water flow as discussed above through the hot water supply line 218, the return line 220, and the circulation device 204 is maintained via the convection forces and the circulation device 204 independent of whether the thermostatically controlled pump is on or off.

[0072] In the illustrated embodiment, the circulation device 204 is positioned adjacent to the top of the small water reservoir 210. In other embodiments, the circulation device 204 can be provided adjacent to the inlet of the tankless water heater 202. In this embodiment, the water flow from the return line 220 passes through the circulation device and into the tankless water heater 202. Accordingly, the continuous flow of water can be instantly heated by the tankless water heater 202 as needed if the water temperature in the fluid circuit drops below a selected temperature. As a result, nearly instantaneous hot water is provided at the faucet and any other hot water outlets in a home or building at all times.

[0073] It can be seen that embodiments of the present invention can provide a fluid circuit and/or water heater 20 (electric or gas) with automatic recirculation of water in order to provide hot water to faucets and any other hot water outlets in a home or building at all times. While the components and methods disclosed herein have been described and shown with reference to particular operations performed in a particular order, it will be understood that these operations may be combined, subdivided, or reordered to form equivalent methods without departing from the teachings of the present invention. Accordingly, unless specifically indicated herein, the order and grouping of the operations is not a limitation of the present invention.

[0074] It should be appreciated that reference throughout this specification to "one embodiment" or "an embodiment" or "one example" or "an example" means that a particular feature, structure, or characteristic described in connection with the embodiment may be included, if desired, in at least one embodiment of the present invention. Therefore, it
should be appreciated that two or more references to “an embodiment” or “one embodiment” or “an alternative embodiment” or “one example” or “an example” in various portions of this specification are not necessarily all referring to the same embodiment.

It should be appreciated that in the foregoing description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. Inventive aspects lie in less than all features of a single foregoing disclosed embodiment, and each embodiment described herein may contain more than one inventive feature. While the invention has been particularly shown and described with reference to embodiments thereof, it will be understood by those skilled in the art that various other changes in the form and details may be made without departing from the spirit and scope of the invention.

We claim:

1. A water heater unit connectable to a water flow circuit having a hot water supply line, a hot water return line connected to the hot water supply line, and a cold water supply line, comprising:
   an outer housing;
   a first cold water inlet coupled to the tank and connectable to the cold water supply line;
   a hot water outlet coupled to the tank and connectable to the hot water supply line; and
   a connection chamber within the housing and adjacent to the tank, the connection chamber having a second cold water inlet connectable to the cold water line, a chamber outlet connected to the first cold water inlet of the tank, and at least one return inlet connectable to the hot water return line at a position to allow a substantially continuous flow of return hot water driven by convection forces without the benefit of a recirculation pump, and a valve connected to the return inlet and being moveable between open and closed positions, the valve in the open position allowing recirculated hot water to flow into the chamber from the return line for return into the tank, and the valve in the closed position blocking water from flowing from the chamber through the return line.

2. The water heater unit of claim 1 wherein the chamber outlet has a tubular portion threadably engageable with the first cold water inlet of the water tank.

3. The water heater unit of claim 1 wherein the chamber is positioned immediately adjacent to the tank.

4. The water heater unit of claim 1 wherein the chamber is connected to a water inlet on the top or side of the tank.

5. The water heater unit of claim 1 wherein the housing has at least one access panel that provides access to the return inlet and the cold water inlet of the connection chamber.

6. The water heater unit of claim 1 wherein the connection chamber is fully enclosed by the housing, and wherein the housing has a first access portion that receives the cold water line and a second access portion that receives at least one hot water return line.

7. The water heater unit of claim 1 wherein the housing includes a body portion surrounding the water tank and a cap portion that connects to a top of the body portion, the connection chamber being disposed in the cap portion.

8. The water heater unit of claim 7 wherein the cap portion is moveable between a closed position wherein the connection chamber is enclosed within the cap portion, and an open position wherein the connection chamber is exposed and accessible.

9. The water heater unit of claim 1 wherein the housing, the water tank, and the connection chamber are integrally connected to form a transportable unit connectable to the cold water line and the hot water supply line of a water system in a dwelling.

10. The water heater unit of claim 1, further comprising insulation connected to the housing generally adjacent to the connection chamber.

11. The water heater unit of claim 1 wherein the connection chamber has a plurality of return inlets, each configured to connect to a separate one of a plurality of water return lines.

12. A pumpless hot water recirculation kit for installation in a dwelling having a water flow circuit having a hot water supply line and a cold water supply line, wherein the hot water supply line is connected to a water outlet assembly, and at least one hot water return line is connected to the hot water supply line adjacent to the water outlet assembly, comprising:
   a water heater remote from the water outlet assembly, the water heater having a housing, a tank disposed within the housing, a first cold water inlet coupled to the tank and connectable to the cold water supply line, and a hot water outlet coupled to the tank and connectable to the hot water supply line; and
   a recirculation device adjacent to the tank, the recirculation device having an interior chamber, a second cold water inlet coupled to the chamber connectable to the cold water supply line, a chamber outlet connected to the first cold water inlet of the tank, and a return inlet connectable to the hot water return line to allow a substantially continuous flow of return hot water driven by convection forces without the benefit of a recirculation pump, wherein the connection chamber is accessible to connect to the cold water line and the hot water return line at or through the housing.

13. The kit of claim 12 wherein the recirculation device has a body, a first stub that extends from the body and that defines the chamber outlet, and a second stub spaced apart from the first stub, the second stub extending from the body and defining the return inlet.

14. The kit of claim 13 wherein the first stub is threadable and configured to threadably engage the cold water inlet of the tank.

15. The kit of claim 13 wherein the second stub includes a coupling that provides a watertight fluid coupling between the second stub and the hot water return line.

16. The kit of claim 13 wherein the recirculation device connects directly to the water supply inlet on the top or side of the tank.

17. The kit of claim 12 wherein the housing includes a tank portion and a cap connected to the top of the tank portion, the tank portion substantially surrounding the tank, and the cap at least partially containing the recirculation device, the cap having a first aperture configured to be at
least adjacent to the cold water supply line, and the cap having a second aperture configured to be at least adjacent to the hot water return line.

18. The kit of claim 12 wherein the chamber outlet includes a tubular portion projecting from the body and being threadably engageable with the first cold water inlet.

19. The kit of claim 12 wherein the recirculation device has a plurality of return inlets, each return inlet having a valve therein moveable between open and closed positions and configured to allow water to flow through the return inlet in only one direction toward the chamber.

20. A pumpless water recirculation assembly for convective recirculation of water through a water circuit to a water heater; said water heater having a cold water inlet and a hot water outlet; said water circuit having a hot water supply line, a cold water supply line, and a hot water recirculation line connected to the hot water supply line, comprising:
   a body having an interior chamber;
   an outlet portion coupled to the interior chamber and threadably connectable to the cold water inlet of the tank;
   a first inlet portion coupled to the chamber and sealably connectable to the cold water line;
   a plurality of hot water return inlets coupled to the chamber and sealably connectable to the recirculation line(s) such that at least a segment of the recirculation line is disposed vertically above the water heater, each hot water return inlet having a flow control valve therein configured to allow hot water to flow in one direction from the recirculation line into the chamber and to block water flow in a reverse direction from the chamber through the hot water return inlet; and
   a cover member connectable to the tank to define an interior area and configured to contain at least a portion of the body within the interior area, the cover having a first opening in alignment with the first inlet and a second opening in alignment with the hot water return inlet;

wherein the water recirculation assembly is installable in the water circuit to provide a substantially continuous flow of return hot water driven by convection forces in the water circuit without the benefit of a recirculation pump.

21. The assembly of claim 20 wherein the outlet portion has external threads that threadably engage the cold water inlet of the water tank.

22. The assembly of claim 20 wherein the cover member is a cap that attaches to a top of the water heater.

23. The assembly of claim 20 wherein the outlet portion, the first inlet portion, and the hot water inlets are installable in the water circuit for a retrofit of the water circuit.

24. A continuous hot water supply system connectable to a water supply line and to a flow circuit having a hot water supply line, and a hot water return line connected to the hot water supply line, comprising:
   a water heating assembly coupled to the water supply line, wherein at least a portion of the water supply line extends from the water heating assembly;
   a reservoir remote from the water heating assembly and positioned to receive heated water from the water heating assembly, the reservoir having a first inlet and a first outlet, the first outlet being connectable to the hot water supply line; and
   a circulation device in fluid communication with the reservoir, the circulation device having a second inlet connectable to the water supply line to receive water therefrom, the circulation device having a second outlet in fluid connection with at least one of the water heating assembly and the reservoir, the circulation device having at least one return inlet connectable to the hot water return line and configured to allow a substantially continuous flow of return hot water therethrough driven by convection forces without the benefit of a recirculation pump, and a valve connected to the return inlet and being moveable between open and closed positions, the valve in the open position allowing recirculated hot water to flow into the chamber from the return line, and the valve in the closed position blocking water from flowing from the chamber through the return line.

25. The continuous hot water supply system of claim 24 wherein the water heating assembly is a tankless water heater.

26. The continuous hot water supply system of claim 24 wherein the reservoir includes a heating element activatable to heat water contained in the reservoir.

27. The continuous hot water supply system of claim 24 wherein the circulation device is positioned immediately adjacent to the reservoir.

28. The continuous hot water supply system of claim 24 wherein the circulation device is positioned immediately adjacent to and upstream from the water heating assembly.

29. The continuous hot water supply system of claim 24 wherein the second inlet of the circulation device is connected to the portion of the water supply line, and the second outlet of the circulation device is connected to the first inlet of the reservoir.