US 20100263604A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2010/0263604 A1**

(43) **Pub. Date: Oct. 21, 2010**

**Ziehm et al.**

(54) **WATER HEATER WITH PASSIVE AUTOMATIC HOT WATER CIRCULATION THROUGH A HOME OR BUILDING**

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(21) Appl. No.: **12/826,523**

(22) Filed: **Jun. 29, 2010**

**Related U.S. Application Data**

(62) Division of application No. 11/742,472, filed on Apr. 30, 2007.

(60) Provisional application No. 60/819,687, filed on Jul. 9, 2006.

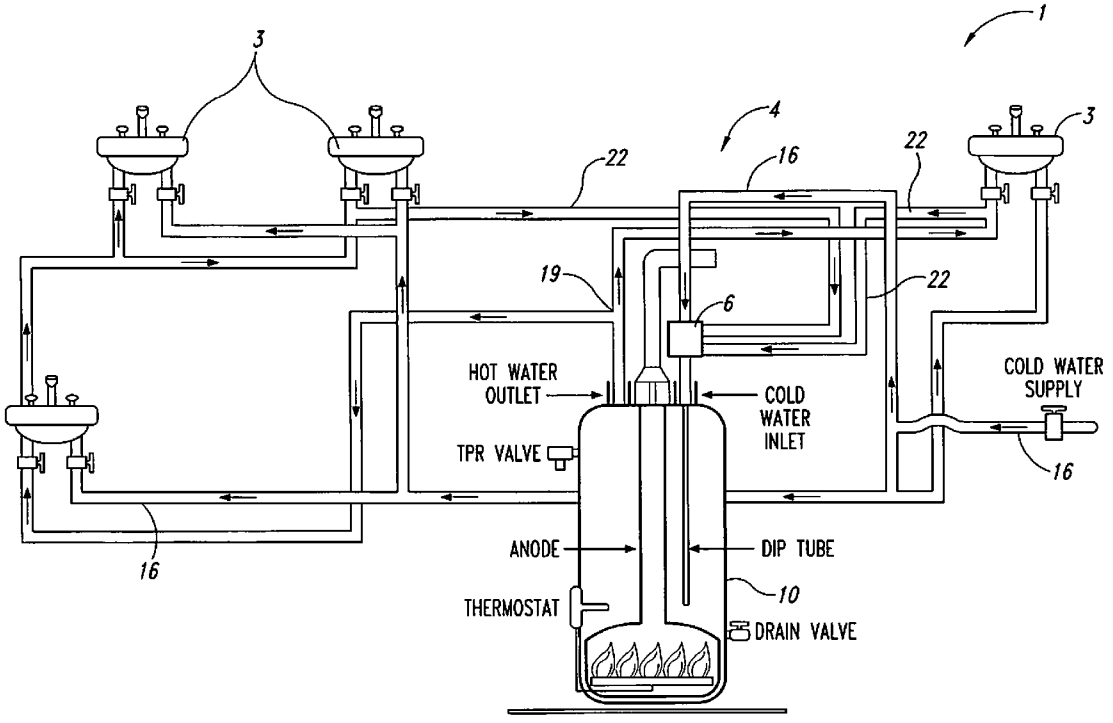
**Publication Classification**

(51) **Int. Cl.**
*F24H 9/12* (2006.01)

(52) **U.S. Cl.** ..... **122/19.1**

(57) **ABSTRACT**

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.



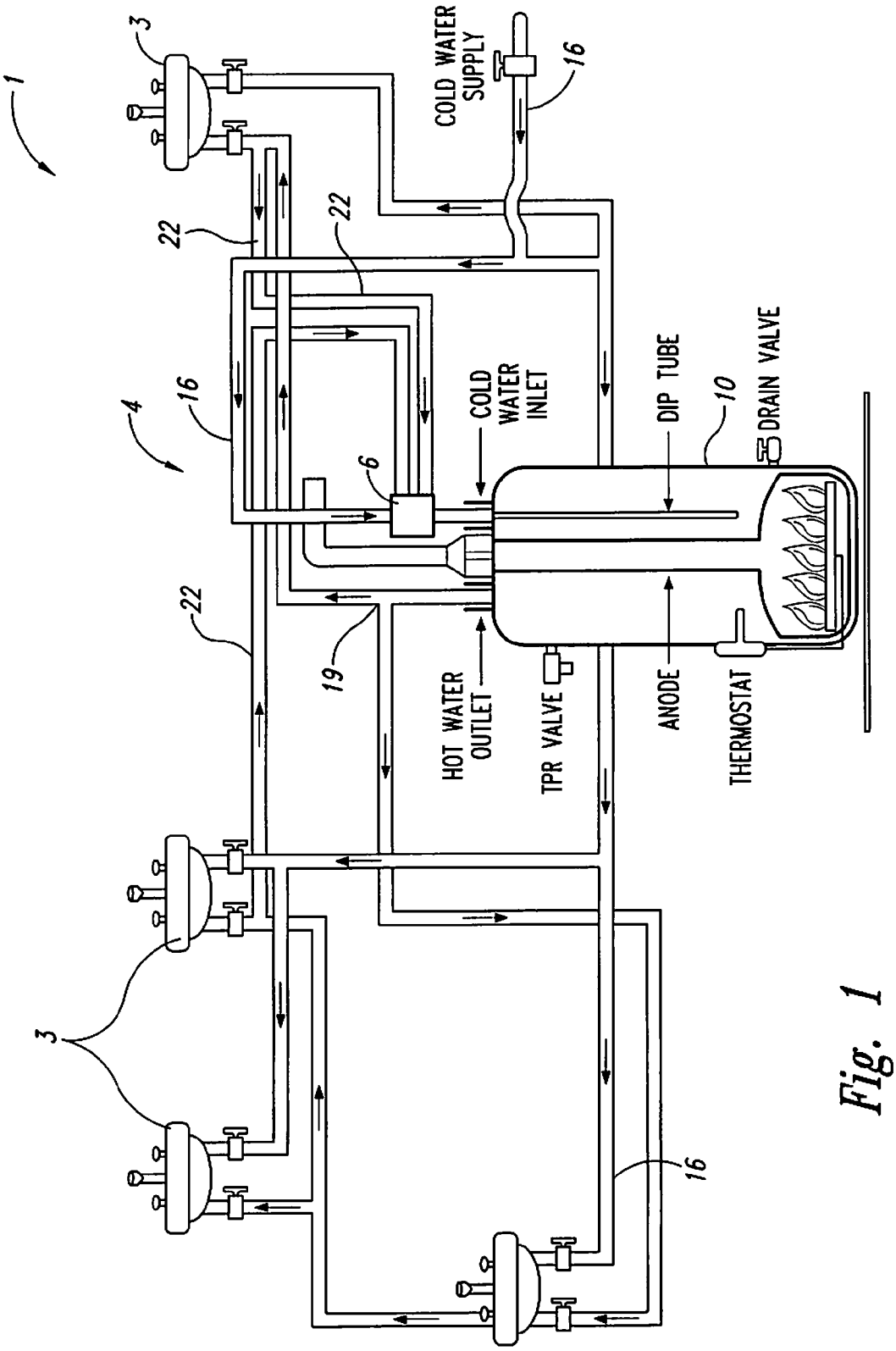

1
3
COLD WATER SUPPLY
16
22
22
4
16
COLD WATER INLET
DIP TUBE
10
DRAIN VALVE
6
22
19
HOT WATER OUTLET
TPR VALVE
ANODE
THERMOSTAT
3
16

Fig. 1

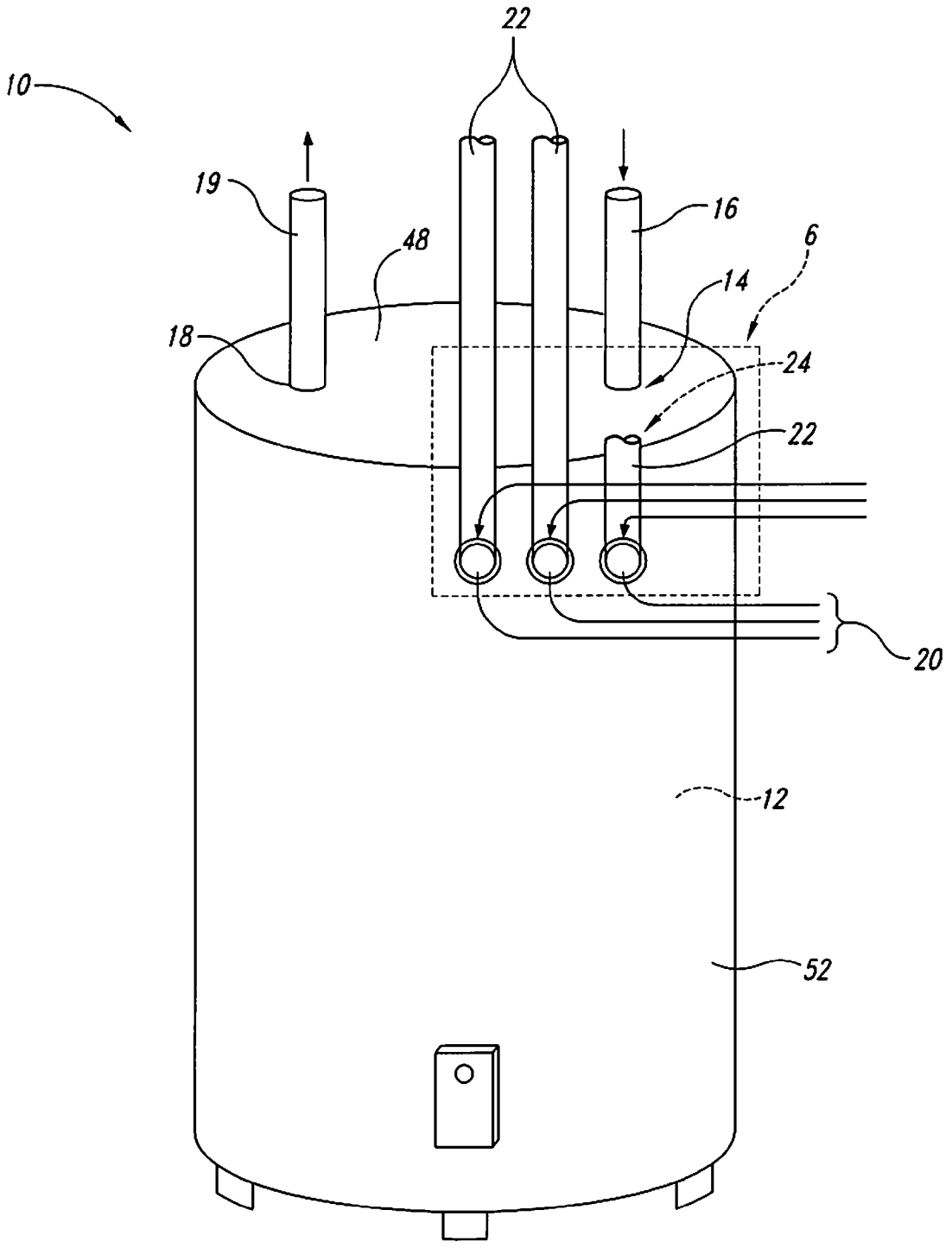



*Fig. 2*

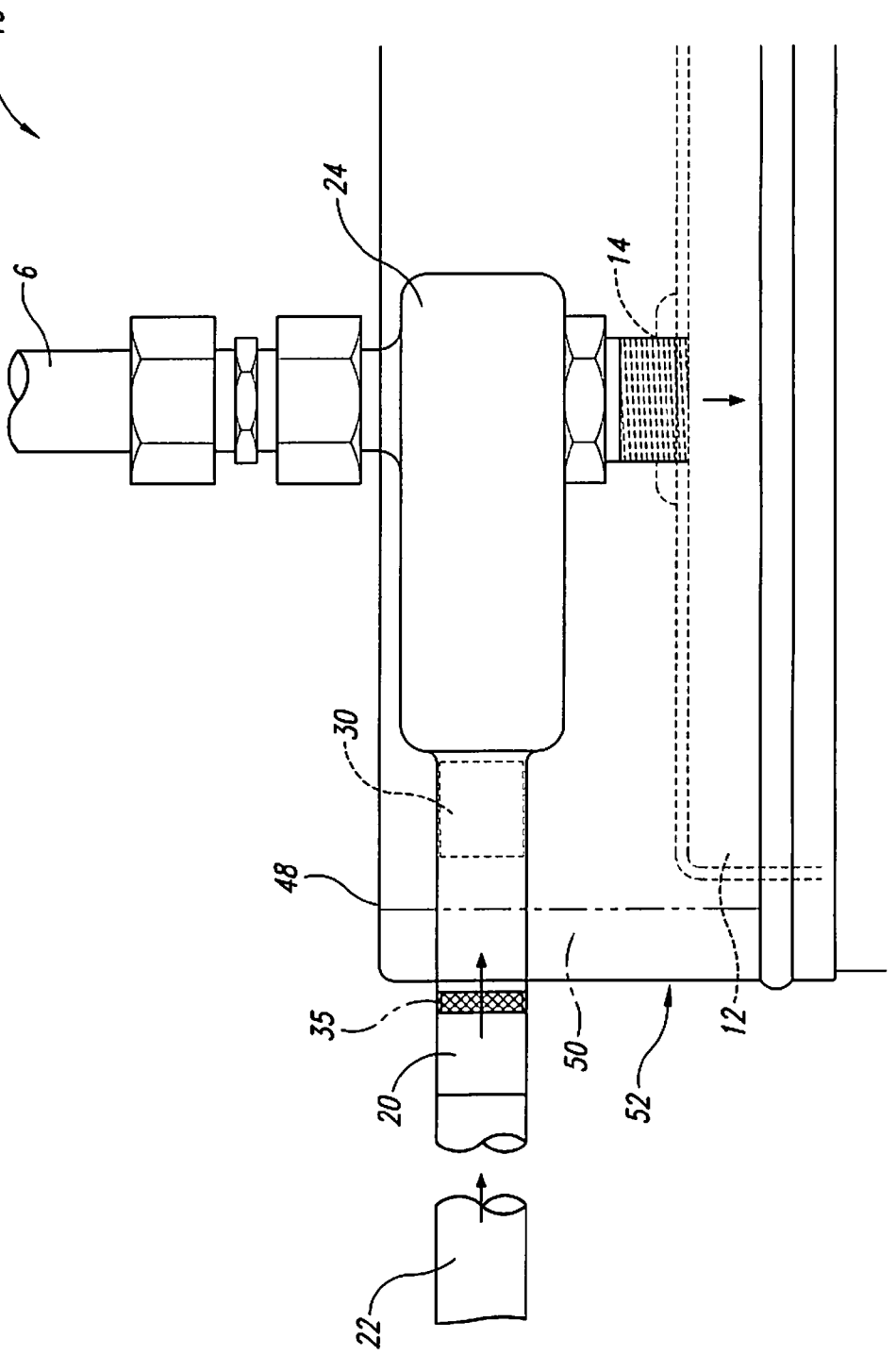



Fig. 3

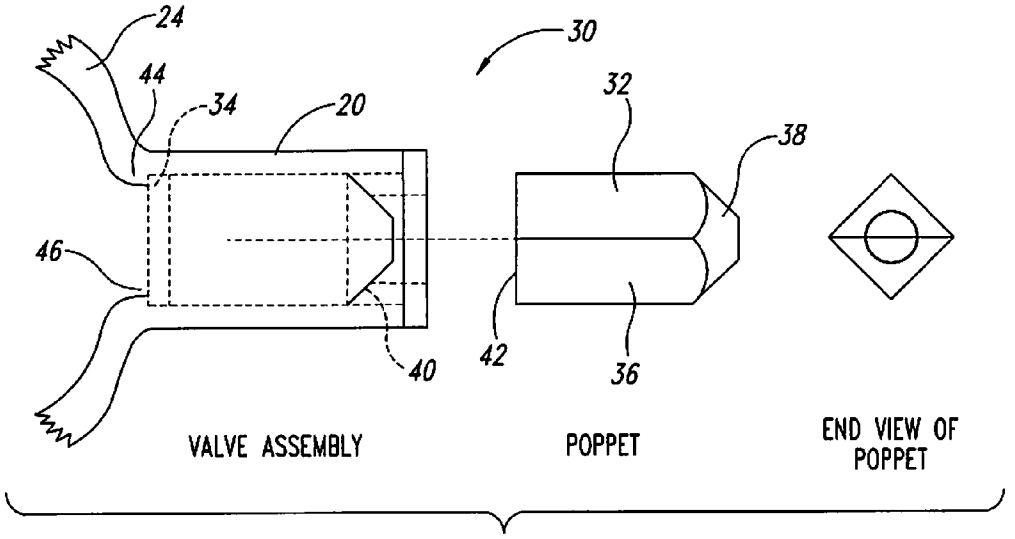
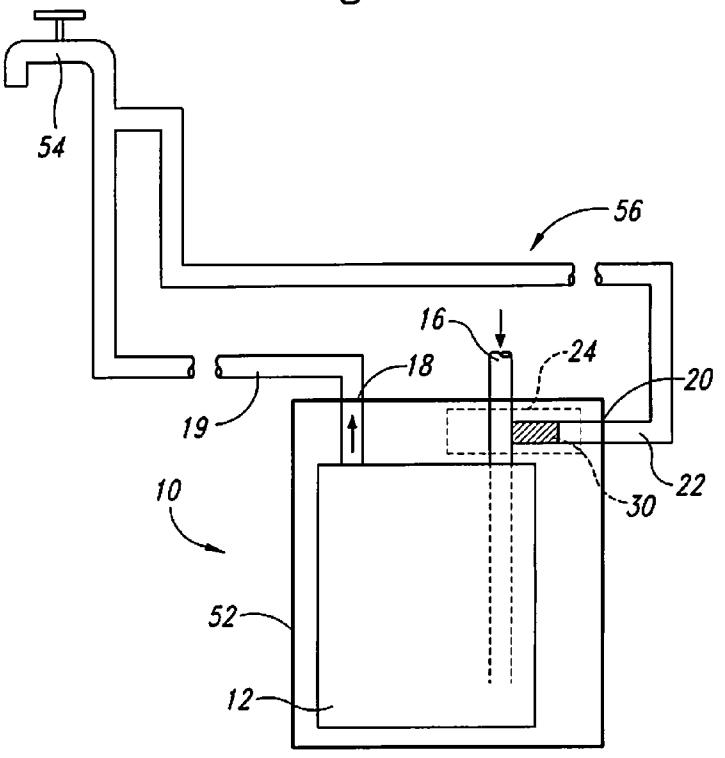

24
44
34
20
30
32
38
46
40
42
36
VALVE ASSEMBLY
POPPET
END VIEW OF POPPET

*Fig. 4*


54
56
16
24
18
20
19
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52
12

*Fig. 5*

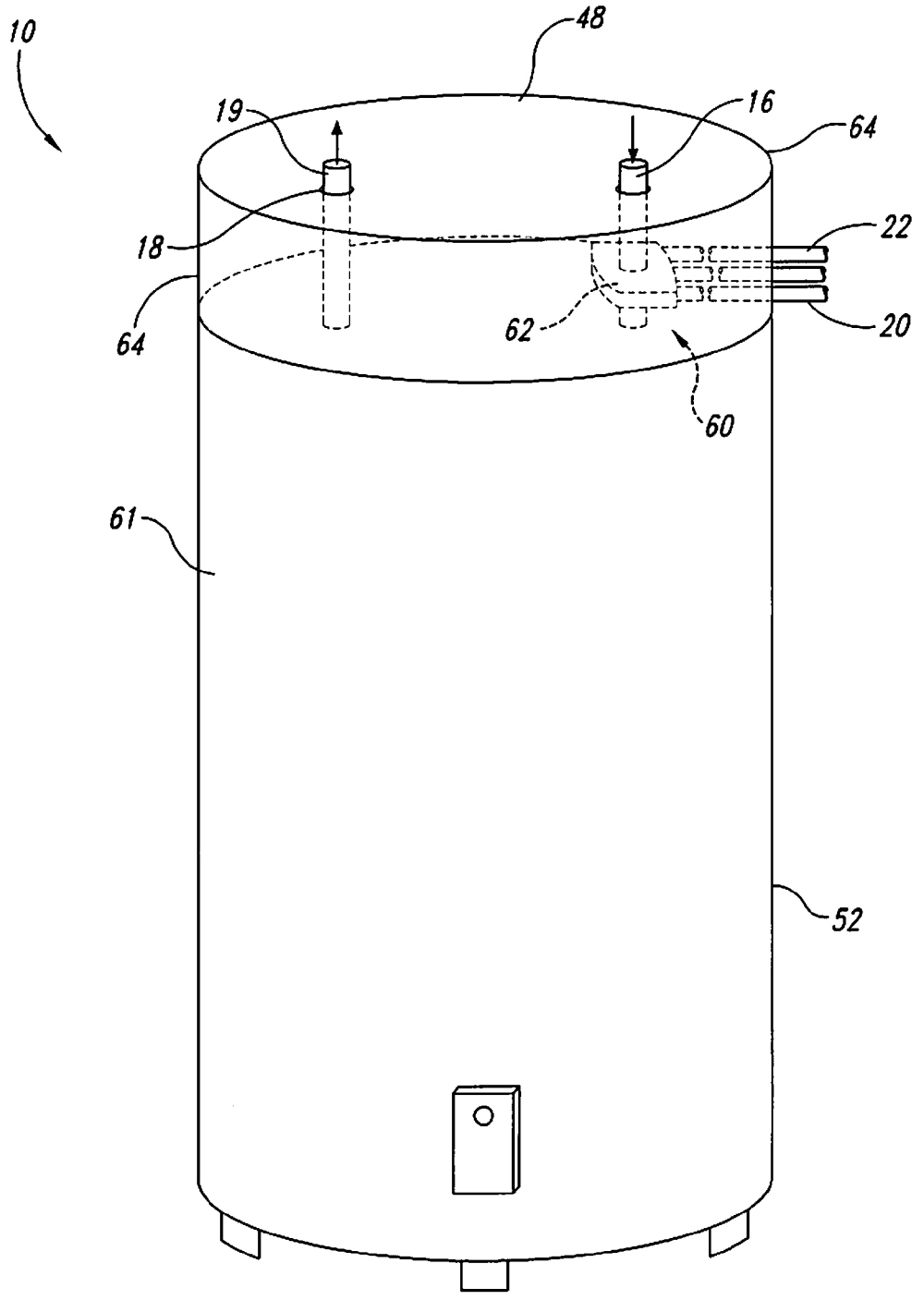


*Fig. 6*

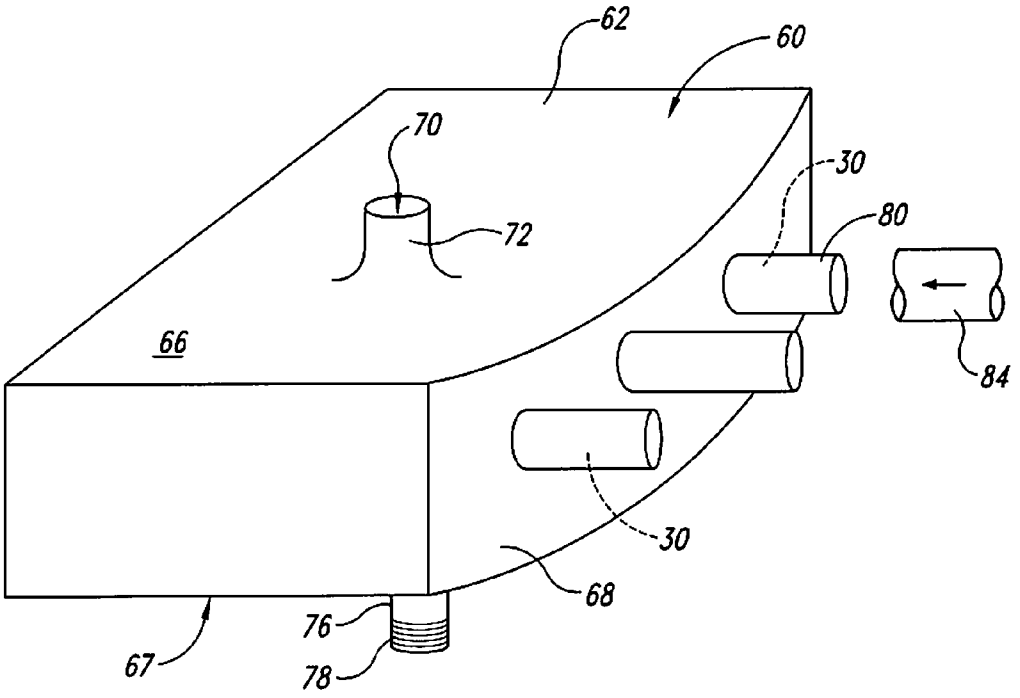


*Fig. 7*

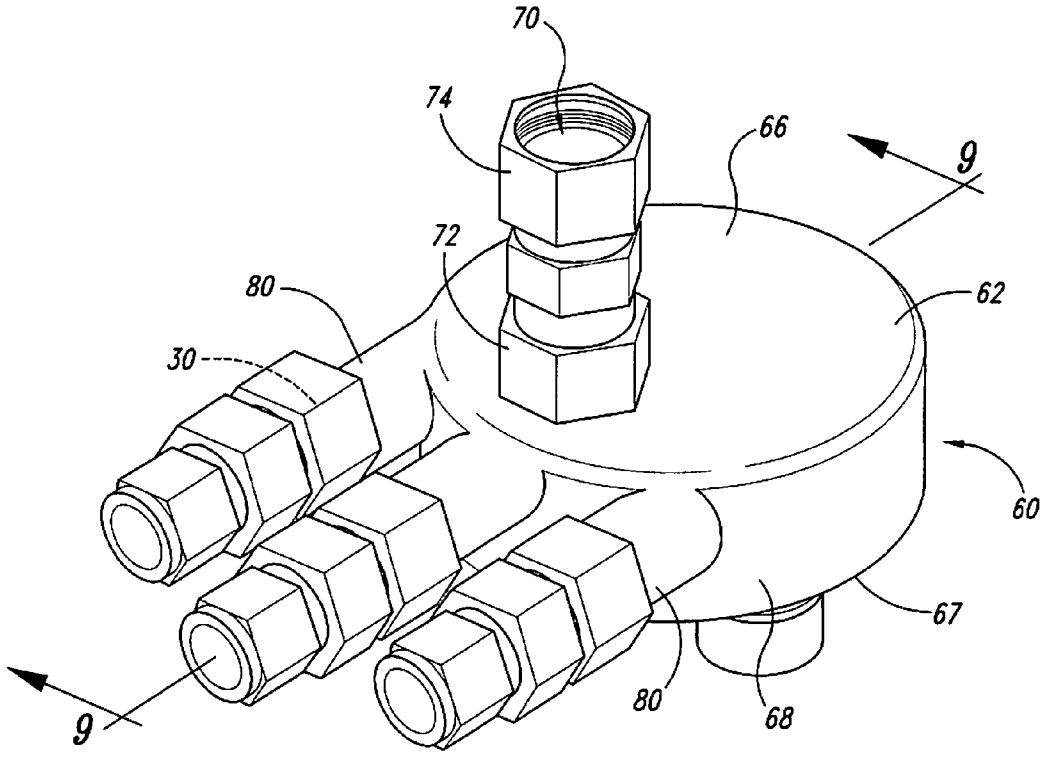


*Fig. 8*

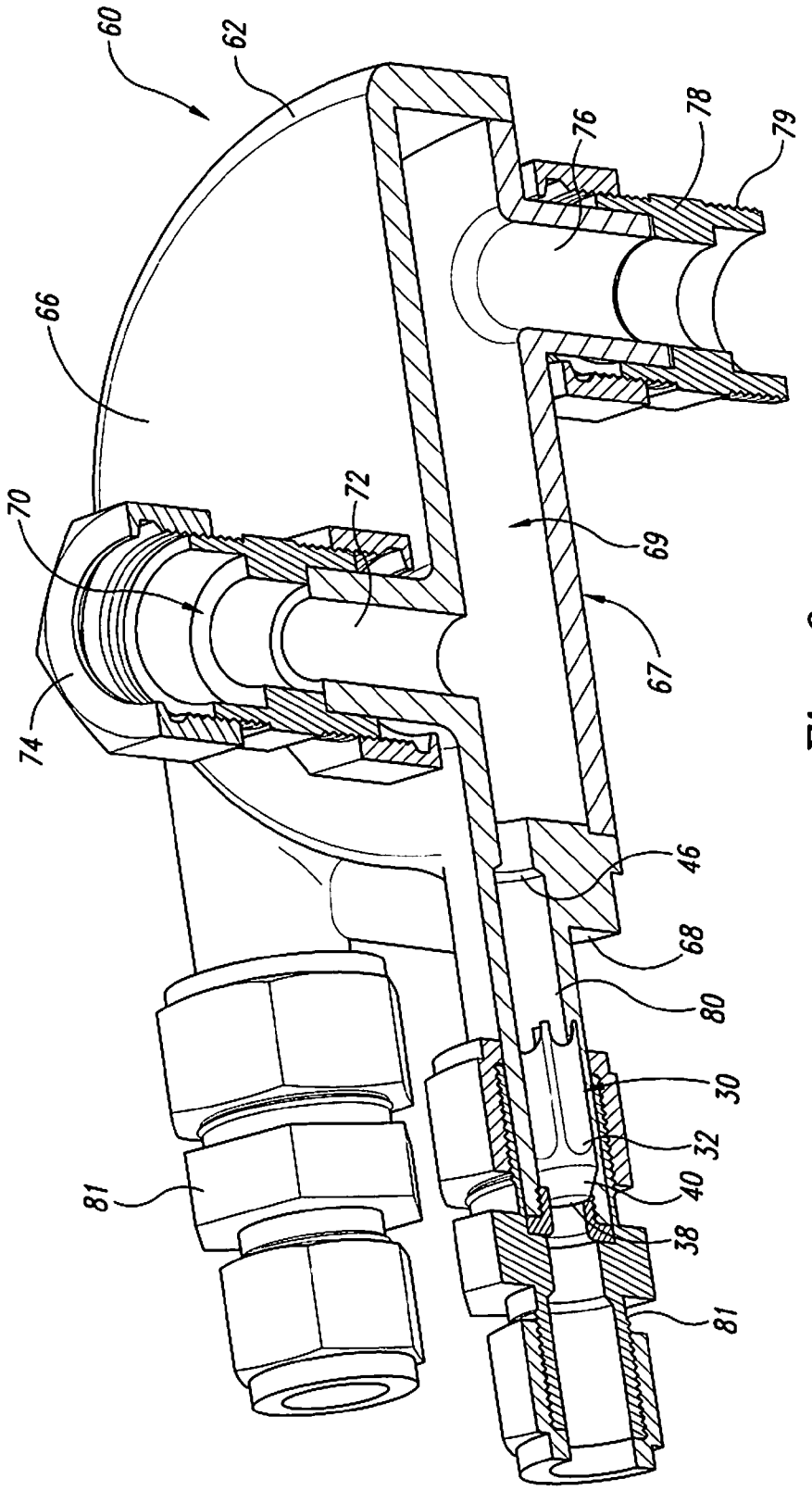


Fig. 9

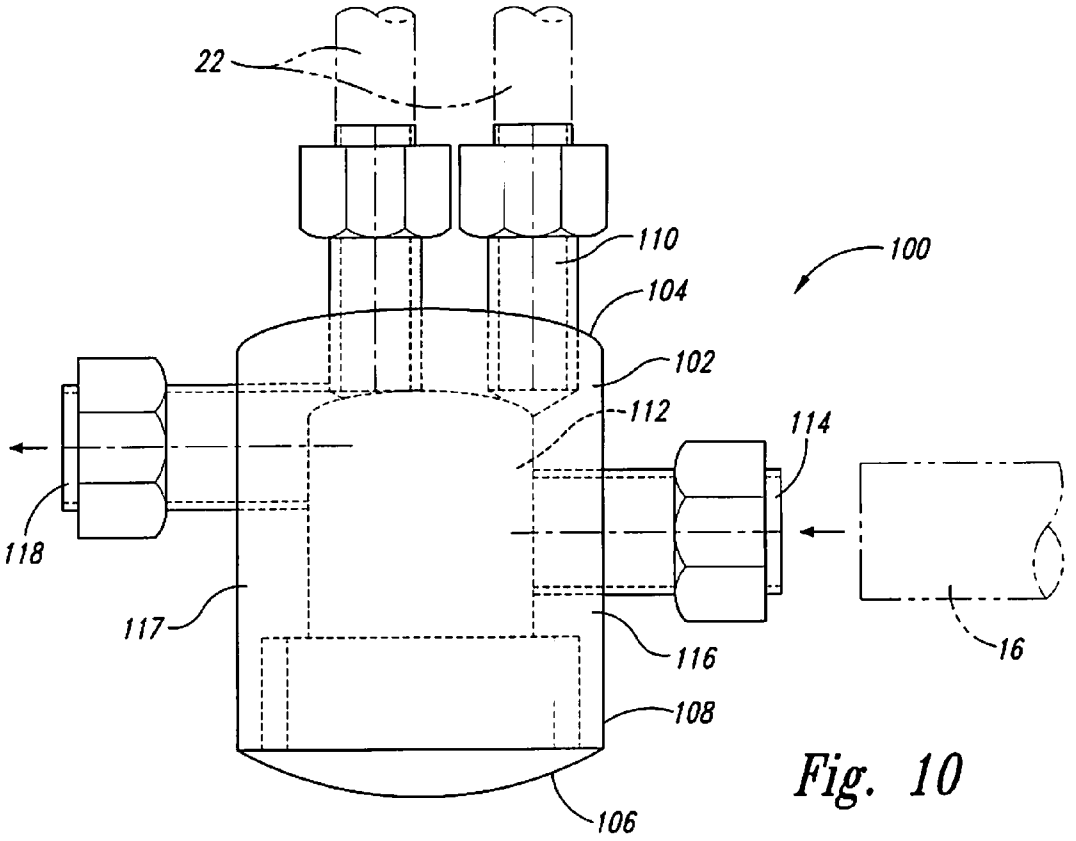
22
110
100
104
102
112
114
118
117
116
16
108
106

Fig. 10

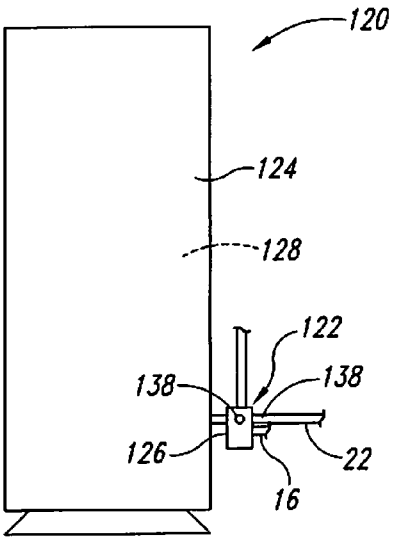
120
124
128
122
138
138
126
22
16

Fig. 11

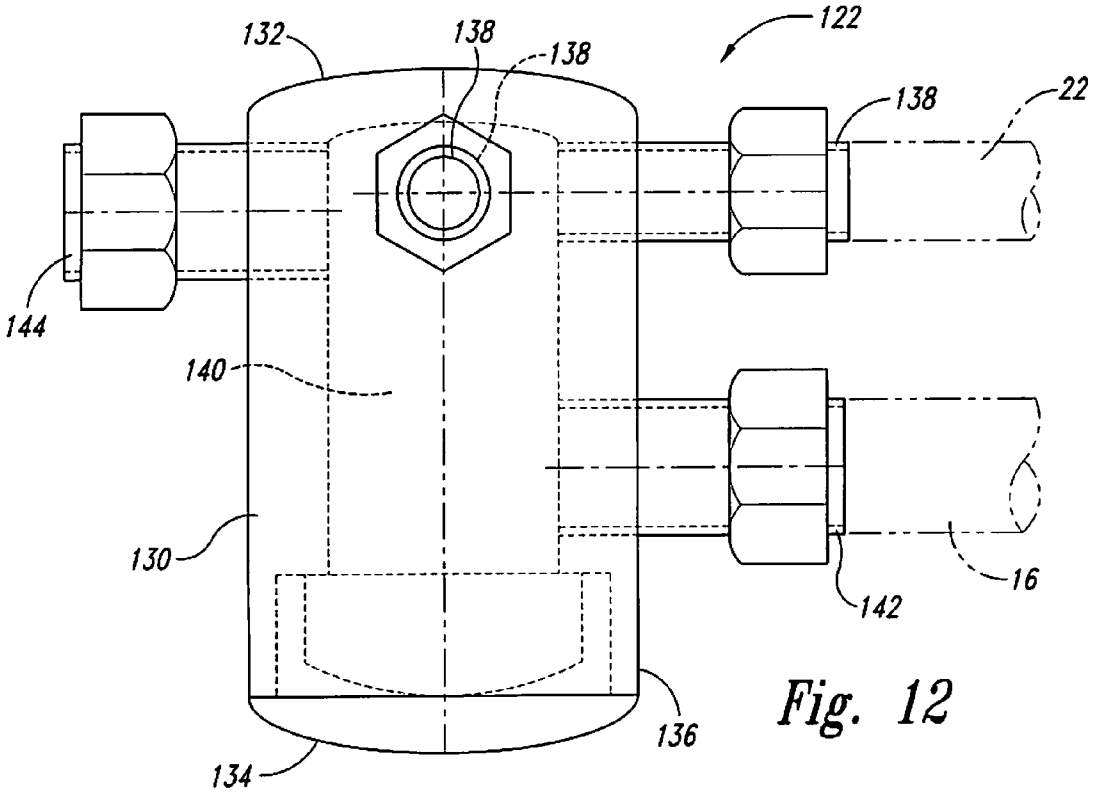
132
138
138
122
138
22
144
140
130
142
16
136
134

Fig. 12

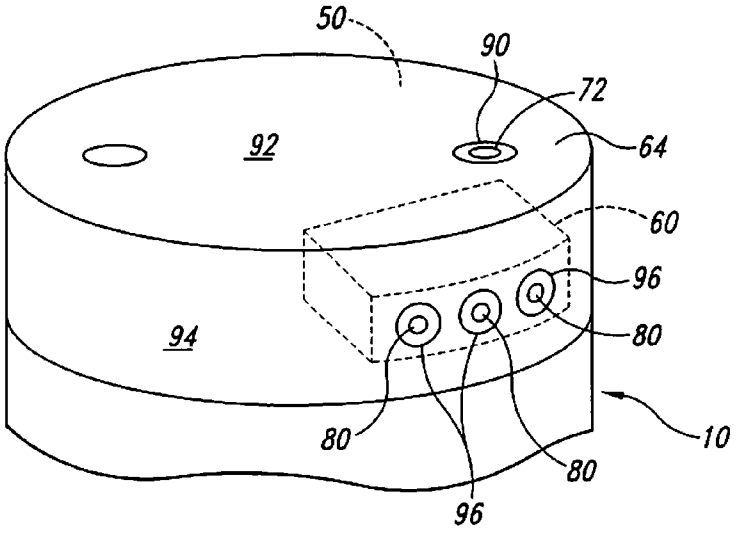
50
90
72
64
92
60
96
94
80
80
10
80
96

Fig. 13

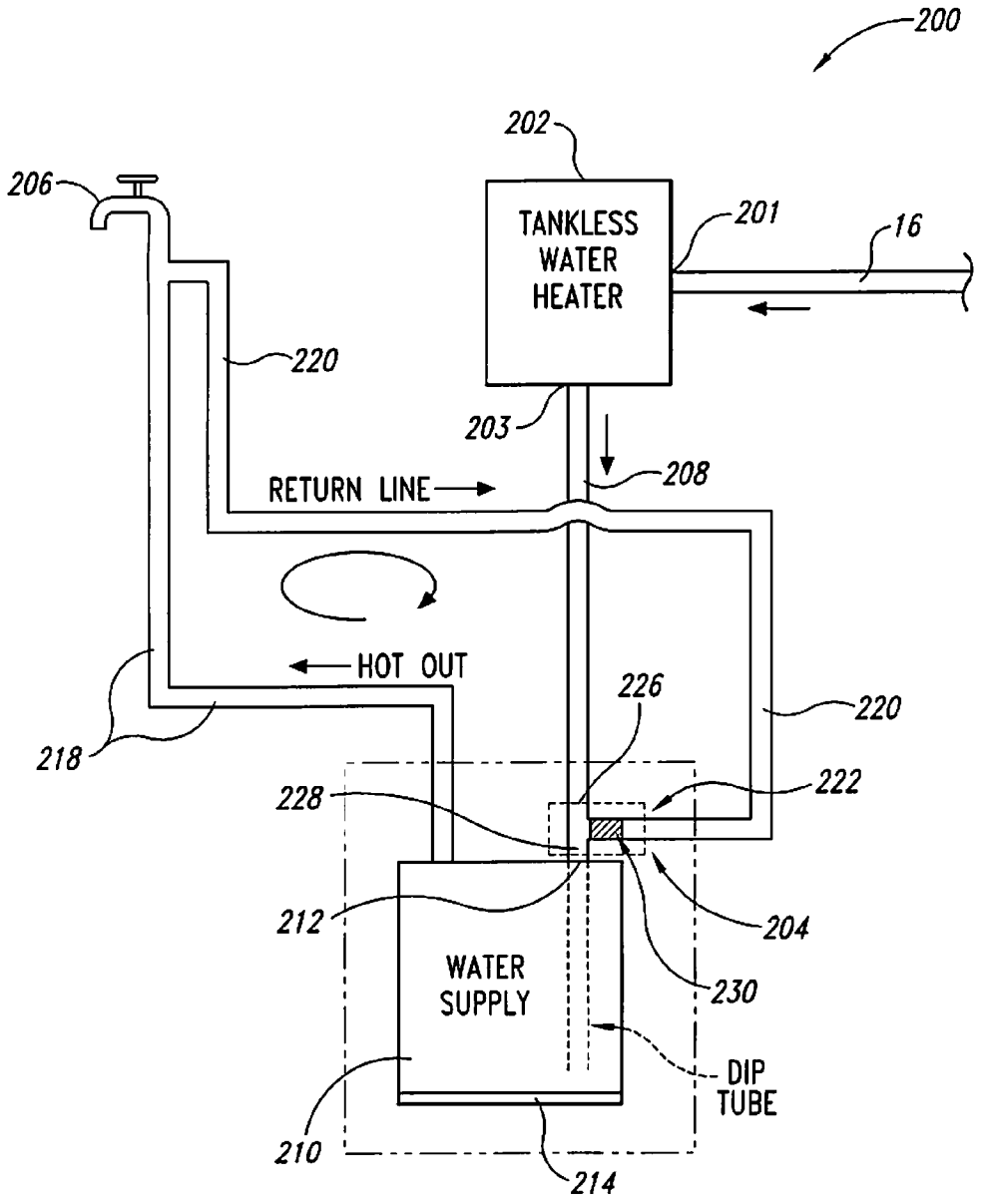
200
202
206
TANKLESS WATER HEATER
201
16
220
203
208
RETURN LINE
HOT OUT
226
220
218
228
222
212
204
WATER SUPPLY
230
DIP TUBE
210
214

*Fig. 14*

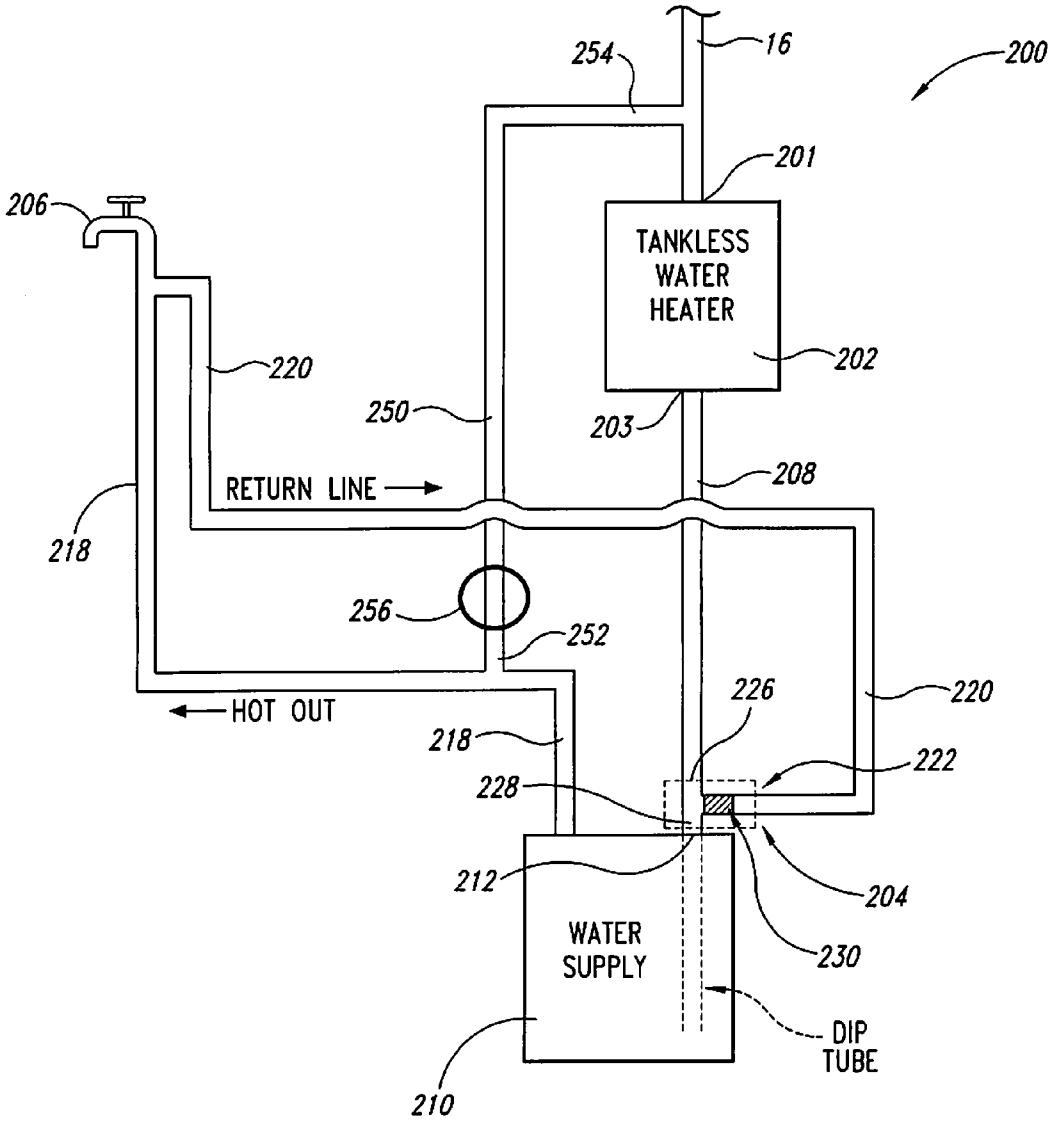
254
16
200
201
206
TANKLESS
WATER
HEATER
220
202
250
203
208
RETURN LINE
218
256
252
220
HOT OUT
226
218
222
228
212
204
WATER
SUPPLY
230
DIP
TUBE
210

*Fig. 15*

# WATER HEATER WITH PASSIVE AUTOMATIC HOT WATER CIRCULATION THROUGH A HOME OR BUILDING

## CROSS-REFERENCE TO RELATED APPLICATION

**[0001]** 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

**[0002]** The present invention is directed toward water distribution systems, and more particularly to hot water supply and circulatory systems.

## BACKGROUND

**[0003]** 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.

**[0004]** 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.

**[0005]** 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.

**[0006]** 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.

**[0007]** 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.

**[0008]** 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.

**[0009]** 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.

**[0010]** 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

**[0011]** 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.

**[0012]** 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 connected 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.

**[0013]** 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 connected 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 fist 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 connected 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, 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 an 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.

**[0036]** In one embodiment, the water heater may have the circulation device positioned inside the top surface of the water heater encased between the heating tank and the top portion of the housing 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.

**[0037]** In another embodiment, a circulation device may be provided as 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.

**[0038]** 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.

**[0039]** 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.

**[0040]** 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.

**[0041]** 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**.

**[0042]** 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.

**[0043]** 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.

**[0044]** 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.

**[0045]** 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, is 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 ¾ 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.

**[0056]** 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.

**[0057]** 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 arcuate 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 **102**. 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).

**[0058]** 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 certain water heaters are now 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**.

**[0059]** 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 arcuate 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.

**[0060]** The circulation device **122** also has a cold water inlet **142** projecting from the sidewall **136** below one of the 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).

**[0061]** 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.

**[0062]** 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.

**[0063]** 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.

**[0064]** 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.

**[0065]** 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 or identical 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**. Alternately, circulation device **204** could be located adjacent to the tankless water heater **202** via with inlet **226** connected to 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 a water heater **10** (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.

**[0075]** 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.

**1-23**. (canceled)

**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.

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