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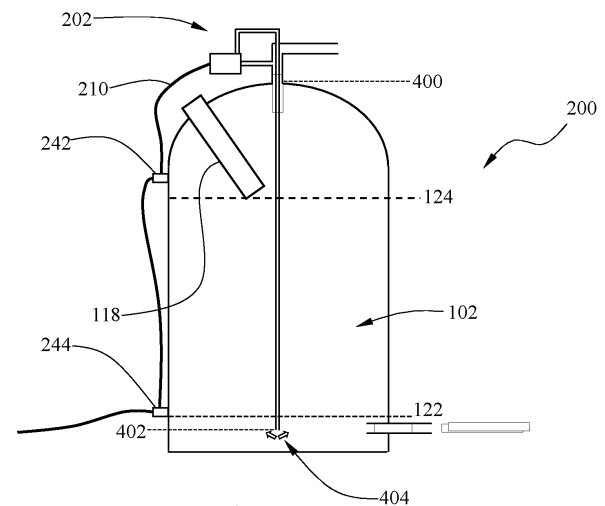
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(54) DEVICE FOR A HOT WATER STORAGE TANK

(57) A device for installation through an outlet of a hot water storage tank, such as a hot water cylinder, the outlet defining an aperture into the hot water storage tank. The device includes a first conduit configured to allow water to be extracted from the hot water storage tank through the aperture, at a first vertical position relative to the hot water storage tank, and a second conduit configured to pass through the aperture and to return the extracted water to the hot water storage tank, the second conduit being configured to terminate within the hot water storage tank at a second vertical position within the hot water storage tank. The second vertical position may be lower than the first vertical position (or may be higher). A pump has an inlet in fluid communication with the first conduit and an outlet in fluid communication with the second conduit or *vice versa*. When installed through the aperture of a hot water storage tank and the pump is operating, water is extracted by the pump from the hot water storage tank through the first conduit, and returned by the pump to the hot water storage tank through the second conduit, or *vice versa*, thereby to transfer the water extracted by the pump to a lower portion of the storage tank where the second conduit terminates or to a higher portion of the storage tank where the first conduit terminates. The net effect is that hot water is moved from a higher to a lower level within the tank or cooler water is moved from a lower level to a higher level within the tank.

**Figure 19**

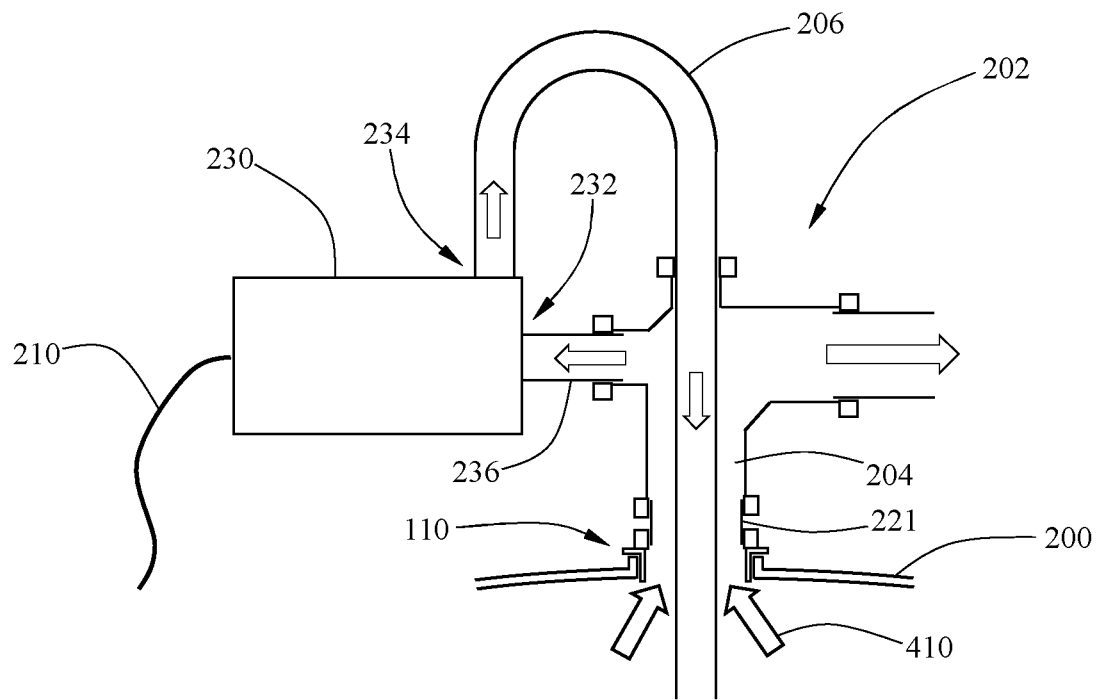


Figure 20

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a device for installation onto a hot water storage tank, such as a hot water cylinder, and to a method of installing such a device. The invention has been developed with a particular focus on retrofitting to installed hot water cylinders, and will largely be described with reference to that application. However, it will be appreciated that the invention can also be implemented as part of any hot water storage tank, including new hot water cylinder installations, whether before or after the tank is installed.

BACKGROUND OF THE INVENTION

[0002] Some hot water cylinders include a resistive heater (sometimes referred to as an "immersion heater") that is used for heating water within the hot water cylinder. Hot water is extracted through an outlet at the top of the cylinder. The outlet can involve BSP connector, such as a ¾" BSP connector.

[0003] Immersion heaters are normally fitted in such a way that they heat only a relatively small volume of water within the cylinder, to avoid heating a large volume when not required. Fitting the immersion heater at or near the top of the cylinder also allows it to be removed and replaced when needed without draining the cylinder.

[0004] For example, an immersion heater can extend diagonally into the cylinder such that it extends around a third of the way down. When turned on, the heater heats the water with which it is in contact. The heated water is more buoyant than the cooler water around it, and will move upwards away from the heater. A convection current forms, as the upward-moving heated water is replaced by cooler water from around the heater.

[0005] To avoid damage to a protruding top fitting during transportation of the hot water cylinder, a BSP female outlet, such as a ¾" BSP outlet in a typical domestic installation can be used. Other sizes and types of outlet connectors can be used to suit different applications.

[0006] To reduce convection losses of hot water from the cylinder, a 90-degree bend is often installed close to the top of the cylinder, followed by a straight length of horizontal pipe. This can reduce or prevent upward migration of heat into the plumbing system.

[0007] The heater's position, and the tendency of water to stratify in such an arrangement, means that the heater cannot heat water that is positioned beneath it in the hot water cylinder.

[0008] An issue can arise with the use of such arrangements with excess power diverters. A source of power, typically a photovoltaic array, is connected to the power diverter, which in turn is connected to a resistance heater within the hot water cylinder. When the photovoltaic array is generating power in excess of the current electric load, the excess is sent to the heater rather than returned to the

grid.

[0009] Also, it is common to have overnight energy rates much lower than peak daytime rates, but the position of a typical immersion heater significantly limits the proportion of the water in the cylinder that can be heated.

[0010] In the arrangement described above where the heater is positioned relatively high up in the hot water cylinder, only the water above the heater will be heated and energy stored. This leaves more than half of the cylinder at a cooler temperature, unable to accept additional excess energy in the form of stored hot water. A typical cylinder may store only enough hot water for one or two showers.

[0011] It is an object of the invention to address one or more of the disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0012] In accordance with a first aspect, there is provided a device for installation through an outlet of a hot water cylinder, the outlet defining an aperture into the hot water cylinder, the device comprising:

a first conduit configured to allow water to be extracted from the hot water cylinder through the aperture, at a first vertical position relative to the hot water cylinder;

a second conduit configured to pass through the aperture and to return the extracted water to the hot water cylinder, the second conduit being configured to terminate within the hot water cylinder at a second vertical position within the hot water cylinder, the second vertical position being lower than the first vertical position; and

a pump, to be positioned, in use, external to the hot water cylinder, the pump having an inlet in fluid communication with the first conduit and an outlet in fluid communication with the second conduit; the device being configured such that, when installed through the aperture of a hot water cylinder and the pump is operating, water is extracted by the pump from the hot water cylinder through the first conduit, and returned by the pump to the hot water cylinder through the second conduit, thereby to transfer the water extracted by the pump to a lower portion of the cylinder where the second conduit terminates.

[0013] Such a device may be easily fitted to a hot water cylinder (including retrofitted to an existing hot water cylinder) without the need to provide additional inlets or outlets into and out of the cylinder.

[0014] The second conduit may be coaxial with the first conduit over at least a portion of the length of each of the first and second conduits. Optionally, the second conduit may extend within the first conduit over at least a portion of the length of each of the first and second conduits. This may make the device simpler, more compact and/or make it easier to maximise flow rates through either or

both conduits.

[0015] The first conduit may comprise a vertically extending portion, the second conduit exiting the first conduit at an upper end of the vertically extending portion.

[0016] The first conduit may comprise a horizontal branching portion, the inlet of the pump being fluidly connected to the horizontal branching portion.

[0017] The second conduit may be configured to extend at least 0.5 m into the hot water cylinder from the aperture. Optionally, the second conduit is at least 1 m long.

[0018] The second conduit may optionally be trimmable at the point of installation, such that the second vertical position is at a desired distance from a bottom and/or top of the hot water cylinder.

[0019] The second conduit may be formed from a plastically deformable material, thereby allowing it to be bent to a desired shape before installation onto a hot water cylinder.

[0020] The second conduit may at least partly be formed from annealed copper.

[0021] The outer diameter of the second conduit may be less than 12 mm, and optionally 10 mm or less.

[0022] The pump may have a capacity of less than 6 litres/minute.

[0023] The device may be configured such that the pump operates at least partly in response to the temperature of water at a third vertical position being at or above a first predetermined threshold. The third vertical position is optionally at or below the first vertical position.

[0024] The device may be configured such that the pump operates at least partly in response to the temperature of water at a fourth vertical position being below a second predetermined threshold. Optionally, the fourth vertical position is at or above the second vertical position.

[0025] The device may comprise at least one temperature sensor and/or thermostat for sensing a temperature of the hot water cylinder, and/or water within the hot water cylinder, at at least one vertical level of the hot water cylinder, for use in controlling the pump.

[0026] In accordance with a second aspect, there is provided a method of retrofitting the device of the preceding aspect to a hot water cylinder, the method comprising:

inserting at least a portion of the second conduit through the aperture such that a lower end of the second conduit terminates at the second level; and attaching the device to the hot water cylinder.

[0027] Optionally, the method may comprise: prior to inserting the portion of the second conduit through the aperture, bending, shaping, and/or trimming at least part of the second conduit along its length so as to adapt the device to the hot water cylinder to which it is to be installed.

[0028] Optionally, the method may comprise:

prior to inserting the portion of the second conduit through the aperture, bending and/or shaping the second conduit to enable it to be inserted through the aperture while avoiding any obstacles;

after inserting at least some of the portion of the second conduit through the aperture, bending and/or shaping the second conduit again, so as to adapt the device to the hot water cylinder to which it is to be installed.

[0029] In a third aspect, there is provided a device for installation through an outlet of a hot water storage tank, the outlet defining an aperture into the hot water storage tank, the device comprising:

a first conduit configured to allow water to be extracted from the hot water tank through the aperture, at a first vertical position relative to the hot water tank; a second conduit configured to pass through the aperture and to return the extracted water to the hot water tank, the second conduit being configured to terminate within the hot water tank at a second vertical position within the hot water tank, the second vertical position being lower than the first vertical position or, in the alternative, higher than the first vertical position; and

a pump, to be positioned, in use, external to the hot water storage tank, the pump having an inlet in fluid communication with the first conduit and an outlet in fluid communication with the second conduit or *vice versa*,

the device being configured such that, when installed through the aperture of a hot water storage tank and the pump is operating, water is extracted by the pump from the hot water storage tank through the first conduit, and returned by the pump to the hot water storage tank through the second conduit, or *vice versa*, thereby to transfer the water extracted by the pump to a lower portion of the tank where the second conduit terminates or, in the alternative, to a higher portion of the tank where the first conduit terminates.

[0030] The device according to this aspect may incorporate the preferred features defined above (and hereinafter) in relation to the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Aspects and implementations will now be described, without limitation and by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic vertical section through a hot water cylinder;

Figures 2 to 4 are simplified vertical sections through the hot water cylinder of figure 1;

Figure 5 is a schematic vertical section through a hot

water cylinder comprising a device according to an embodiment of the invention;

Figure 6 is a schematic of the device of Figure 5;

Figures 7 to 11 are schematic vertical sections through the hot water cylinder of figure 5, with the device in various stages of operation;

Figures 12 and 13 are schematic vertical sections through a hot water cylinder comprising a device according to a further embodiment of the invention;

Figures 14 and 15 are schematic vertical sections through a hot water cylinder comprising a device according to a further embodiment of the invention;

Figures 16 to 19 are schematic vertical sections through a hot water cylinder comprising a device according to a further embodiment of the invention;

Figure 20 is a schematic of a further device according to a further embodiment of the invention; and

Figure 21 is a flowchart showing a method of installing a device, according to further embodiment of the invention.

[0032] It will be appreciated at all drawings are schematic and do not represent all details of the components that they illustrate. Drawings are not to scale unless the contrary is clear from context.

DETAILED DESCRIPTION OF THE INVENTION

[0033] The present disclosure relates to a device and a method for installing such a device. In the examples described, the device is being retrofitted to an existing hot water cylinder and is intended for use with an energy diversion device, such as an immersion diverter as can be used with solar photovoltaic panels. In other implementations, the device can be installed on a new cylinder, and/or can be used with an ordinary timer, switch, or other controller for controlling a resistive heater.

[0034] For convenience, plumbing components will generally define smooth curves, but are sometimes illustrated with sharp edges and corners for convenience and clarity. Similarly, plumbing components such as BSP and compression joints are shown in a highly schematic fashion. Some elements of such components, such as olives, internal stops, screw threads, tapered surfaces, seals, etc., are omitted for clarity.

[0035] Figure 1 shows a domestic hot water cylinder 100. In Figure 1, cylinder 100 can be any vented or unvented hot water cylinder. Cylinder 100 can be formed from, for example, stainless steel, copper, enameled steel, or any other suitable material or combination of materials. Typically, regulations require such hot water cylinders to be insulated, but for clarity, such insulation is not shown in the accompanying drawings.

[0036] Cylinder 100 is generally cylindrical, with a domed upper portion such that the highest point of the hot water cylinder is central to the cylinder in plan.

[0037] In use, cylinder 100 is completely filled with water 102. A cold inlet 104 supplies cold water into the

hot water cylinder 100 near its base, typically from a mains water supply.

[0038] A hot outlet 106 is positioned at the top of cylinder 100. Hot outlet 106 comprises a $\frac{3}{4}$ " BSP female connector, to which is connected 90° elbow 108. One end of elbow 108 is screwed into the $\frac{3}{4}$ " BSP female outlet. Alternatively, an intermediate 22mm compression to $\frac{3}{4}$ " BSP male screw thread screws into the female $\frac{3}{4}$ " BSP thread at the top of the cylinder to which is connected elbow 108. Elbow 108 bends horizontally to join existing hot water plumbing circuits (not shown).

[0039] Cylinder 100 includes a heating circuit comprising, in the example of Figure 1, a heating coil 112. Heating coil 112 includes an inlet 114 that receives heated water from a remote boiler (not shown), and an outlet 116 that returns water to the boiler.

[0040] The heating circuit can include a heat source of any suitable type, including gas, oil, and woodchip boilers, log burners, and air-source and ground-source heat pumps, for example. In other implementations, the primary heating circuit directly heats the water in the cylinder by extracting it, heating it, and returning the heated water to the cylinder. This avoids the need for a heating coil.

[0041] Cylinder 100 includes a resistive electric heating element (sometimes called an immersion heater) 118 that is mounted through an aperture formed in the top dome of cylinder 100. In other implementations, the immersion heater can be installed lower down the cylinder, such that it enters the cylinder at a more oblique angle or horizontally.

[0042] Heating element 118 is screwed to a corresponding boss (not shown) surrounding the aperture. The immersion heater is temperature controlled using its own thermostat. Electrical connections of heating element 118 are omitted for clarity.

[0043] In the implementation of Figure 1, the heating element 118 is positioned off-centre near the top of cylinder 100, and extends about a third of the way down from the top of cylinder 100 towards the bottom, as indicated by dashed line 124.

[0044] An example of the operation of heating element 118 will now be described with reference to Figures 1 to 4, which show a sequence of simplified diagrams showing the temperature of water within cylinder 100 as heating element 118 operates. For clarity, heating coil 112, inlets 104 and 114, and outlets 106 and 116, are omitted from Figures 2 to 4.

[0045] In Figure 1, the water 102 within cylinder 100 is initially cold. Heating element 118 is turned on in Figure 2, and the water immediately around it is heated up. The heated water is less dense than the cooler water around it, and rises due to buoyancy, as shown by arrows 120. The rising heated water continues upwards until it reaches the upper section of the cylinder.

[0046] The hot water within cylinder 100 will tend to stratify to an extent, such that there is a line 122 above which the water temperature significantly increases.

Although line 122 is shown as a thin dashed line, it will be appreciated that line 122 represents the middle of a transition zone of water at different water temperatures. This transition zone may be of varying thickness, and can be dependent upon factors such as turbulence, local thermal conduction within the water, and heat migrating down the cylinder walls, for example.

[0047] Hot water generated by heating element 118 will accumulate in the upper section of the cylinder, as shown by the lower position of line 122 in Figure 3. The process continues while heating element 118 is turned on, until the accumulated hot water reaches line 124 (the lowest point of heating element 118), as shown in Figure 4. At this point, the water heated by the heating element 118 is the same temperature as the water around it, and hence has the same density. The buoyancy that drove movement of water heated by the heating element 118 in Figures 2 and 3 stops. Eventually, the rising temperature around the heating element 118 will cause a thermostat (not shown) within heating element 118 to cut off, which turns off heating element 118.

[0048] Unfortunately, when heating element 118 is installed in cylinder 100 at a relatively high vertical position, such as is shown in Figure 1, for example, stratification within cylinder 100 limits the volume of water that can be heated by heating element 100.

[0049] Turning to Figure 5, there is shown a cylinder 200. Cylinder 200 has several features that are similar to those described in relation to cylinder 100, and such features are indicated with the same reference signs as were used in relation to cylinder 100.

[0050] Cylinder 200 comprises a device 202 in accordance with an embodiment, which has been installed through the existing top outlet of cylinder 200. The outlet defines an aperture into cylinder 200 through which hot water can be extracted as described below.

[0051] As best shown in Figure 6, device 202 comprises a first conduit 204, which is attached to cylinder 200 by way of a BSP fitting 110. The interior of first conduit 204 is in fluid communication with an interior of cylinder 200, and is configured to allow water to be extracted from inside cylinder 200 through the aperture, at a first vertical position (indicated by dashed line 400) relative to cylinder 200.

[0052] In this implementation, the first vertical position 400 is at the top of the interior of cylinder 200 where the BSP fitting terminates, but in other implementations the first vertical position can be different. Also, in this implementation, the first conduit does not, itself, extend into the cylinder. In other examples, the first conduit 204 itself can extend some distance into cylinder 200, such that it takes water from a position below where bubbles might exist (for example).

[0053] First conduit 204 comprises a first T-connector 216 and a second copper T-connector 218. First T-connector 216 takes the form of a 22 mm x 15 mm x 22 mm copper fitting, comprising a first crossbar 222 that extends vertically as installed in Figure 6, and a first branch

220 that extends horizontally from first crossbar 22 as installed in Figure 6. First branch 220 terminates in a 15 mm compression joint, and the upper and lower ends of first crossbar 222 each terminates in a 22 mm compression joint.

[0054] Second T-connector 218 takes the form of a 22 mm x 22 mm x 15 mm copper fitting, comprising a second crossbar 226 that extends vertically as installed in Figure 6, and a second branch 224 that extends horizontally from second crossbar 226 as installed in Figure 6. Second branch 224 and the lower end of second crossbar 226 each terminates in a 22 mm compression joint, and the upper end of second crossbar 226 terminates in a 15 mm compression joint.

[0055] The 22 mm compression joint at the lower end of first crossbar 222 is compression fitted to a short piece of 22 mm copper pipe 221 extending from BSP fitting 110 (which comprises a male $\frac{3}{4}$ " BSP to 22 mm compression joint connector attached to a female $\frac{3}{4}$ " BSP connector at the top of cylinder 200). The 22 mm compression joint at the upper end of first crossbar 222 is connected to the 22 mm compression joint at the lower end of second crossbar 226 by way of a further piece of 22 mm copper pipe 227. In this way, at least some of the interior of first T-connector 216 and second T-connector 218 define first conduit 204, as will be described in more detail below.

[0056] Device 202 also comprises a second conduit 206 configured to pass through the aperture, allowing it to return the extracted water to the hot water cylinder 200 as described in more detail below. Second conduit 206 is configured to terminate within the hot water cylinder 200 at a second vertical position (indicated by dashed line 402) within cylinder 200, the second vertical position 402 being lower than the first vertical position.

[0057] Second conduit 206 takes the form of a 10 mm annealed copper tube, which extends upwards from the second vertical position 402 through cylinder 200, through the interior of first crossbar 222 and second crossbar 226, before being sealed to the 15 mm compression joint at the upper end of second crossbar 226 (a 15-10 mm reducer is used for this purpose, but for clarity is not illustrated). A short section of second conduit 206 extends upwards from the 15 mm compression joint (and reducer).

[0058] In this implementation, second conduit 206 is coaxial with first conduit 204 over at least a portion of the length of each of the first and second conduits. While second conduit 206 is centred coaxially within the first conduit 204, it will be appreciated that this need not necessarily be the case in other implementations.

[0059] In this implementation, the second vertical position 402 is near the base of the interior of cylinder 200, which offers a large increase in the amount of water that can be heated by heating element 118, without being so low in cylinder 200 as to potentially stir up debris that may settle on the bottom of cylinder 200 over time.

[0060] In other implementations the second vertical position 402 can be different. For example, the second

conduit 206 can terminate about a third of the way up from the bottom of cylinder 200, or at any other position considered suitable for the particular implementation.

[0061] In other implementations, the second conduit may be configured to extend at least 0.5 m into the hot water cylinder from the aperture. In yet other implementations, the second conduit is at least 1 m long, but can be longer. For example, the second conduit can be sufficiently long that it can extend at least 50%, and preferably at least 75% of the distance from the aperture to a base of the cylinder.

[0062] Optionally, the second conduit is designed to be trimmable at the point of installation, such that the second vertical position 402 is at a desired distance from a bottom and/or top of the particular hot water cylinder to which the device is being installed. Trimming of the second conduit during installation is described in more detail below. Alternatively, the second conduit can be supplied at a shorter length, and an additional length of tube of suitable length joined on during the installation process.

[0063] Optionally, the second conduit is formed from a plastically deformable material (such as annealed copper), thereby allowing it to be bent to a desired shape before or during installation onto a hot water cylinder.

[0064] A vertical distance between the first and second vertical positions, as indicated by arrow 208 in Figure 5, represents (approximately) an additional volume of water that can potentially be heated by heating element 118, relative to the volume that can be heated by the arrangement shown in Figure 1. This can, for example, increase the amount of available hot water by two, three, or even more times, depending upon the vertical installation position and length of the heating element, the length of second conduit, and other factors that will be apparent to the skilled person.

[0065] Device 202 comprises a pump 230 positioned external to cylinder 200. Pump 230 has an inlet 232 and an outlet 234. Inlet 232 is connected to the 15 mm compression joint at the end of first branch 220 by way of a piece of 15 mm copper pipe 236. Outlet 234 is connected to the upper end of second conduit 206 by way of a piece of 10 mm pipe 238 and a 10 mm 90° elbow compression joint connector 240.

[0066] In other implementations (see Figure 20 for example), second conduit 206 continues in one piece through a path similar to that of elbow 240 and pipe 238.

[0067] Pump 230 is a 12 V centrifugal type pump that is powered by way of a 12 V power supply (not shown) and a power cord 210. The type, capacity and/or rated power of pump 230 can be selected to suit implementation requirements. It is desirable that the pump characteristics be selected such that it does not cause excessive de-stratification so as not to disturb the hot water banding in the top of the cylinder or stir up sediment. Similarly, the power supply can optionally be adjustable to allow fine-tuning of the operating characteristics of the device. For example, the power supply can be configured to initially operate at

full power for a period, which may help mitigate potential airlocks by pushing air through the device, and then reduce the power in order to reduce the rate at which water is pumped through the second conduit.

[0068] By way of non-limiting example, the pump may have a capacity of less than 6 litres per minute. For example, the pump can be configured to deliver 5 litres per minute. Optionally, the pump can have a pressure rating of 1 metre head at zero flow.

[0069] In some implementations, device 202 can be operated by way of a switch (not shown) and/or a timer that controls supply of power to pump 230 by way of power cord 210.

[0070] Operation of this implementation of device 202 will now be described with reference to Figures 5 and 7 to 9, which show a sequence of simplified diagrams showing the temperature of water within cylinder 200 as heating element 118 operates. For clarity, heating coil 112 is omitted from Figures 7 to 9.

[0071] In Figure 5, the water 102 within cylinder 200 is initially cold. Heating element 118 is turned on in Figure 7 (manually, by way of a timer, or due to operation of an excess power diverter from a solar photovoltaic array or other source of power, for example) and the water immediately around it is heated up. The heated water is less dense than the cooler water around it, and rises due to buoyancy, as shown by arrows 120. The rising heated water continues upwards until it reaches the upper section of the cylinder. Hot water generated by heating element 118 will accumulate in the upper section of the cylinder, as shown by line 122 in Figure 7.

[0072] The process continues while heating element 118 is turned on, until the accumulated hot water reaches the level heating element 118, as shown in Figure 8. At this point, the water heated by the heating element 118 is the same temperature as the water around it, and hence has the same density. The buoyancy that drove movement of water heated by the heating element 118 in Figure 7 stops. Eventually, the rising temperature around the heating element 118 causes a thermostat (not shown) within heating element 118 to cut off, turning off the heating element 118.

[0073] At any time up to and beyond the point which heating element 118 is cut off due to operation of its thermostat, device 202 can be turned on by manual operation of the switch (not shown) and/or by operation of the timer (not shown). (Thermostat-controlled operation is described below with reference to a different implementation).

[0074] Figures 9 to 11 show what happens within cylinder 200 when device 202 is switched on, for example after heating element 118 has cut off.

[0075] In Figure 9, pump 230 is turned on. Pump 230 sucks water from cylinder 200 through first conduit 204, as shown by arrows 410. Because first conduit 204 extracts water from the top of cylinder 200, the extracted water is relatively hot compared to most of the rest of the hottest water within cylinder 200. As best shown in Figure

6, the extracted water is drawn by pump 230 through first crossbar 222, second crossbar 226, second branch 224, and pipe 236 to inlet 232 of pump 230. Pump 230 pumps the water through outlet 234, pipe 238, elbow 240, and down through second conduit 206, until it exits at the bottom end of second conduit 206 as shown by arrows 404.

[0076] The net result of this operation is that water extracted by pump 230 from the first vertical position is moved to the second vertical position 402 at a lower portion of cylinder 200 where second conduit 206 terminates.

[0077] The hot water exiting the lower end of second conduit 206 will generally tend to rise upwards, as shown generally by arrows 406 (although the actual path may not be exactly as illustrated). As the water approaches line 122, it joins the mass of hot water in the top of the cylinder as shown by arrows 408.

[0078] Extracting hot water from cylinder 200 above heating element 118 causes cooler water from lower in cylinder 200 to move upwards such that heating element 118 is no longer surrounded by hot water. Eventually, the thermostat within heating element 118 will reach a temperature that causes it to turn heating element 118 on again. Since heating element 118 is now surrounded by cooler water, it is able to heat that water without immediately causing its thermostat to reach cut-off temperature.

[0079] Depending upon factors such as the rate at which hot water is extracted from the top of cylinder 200, the amount of power being output by heating element 118, and the amount of mixing of the hot water outputting the lower end of second conduit 206, device 202 can be operated either continuously, or intermittently as the thermostat of heating element 118 turns power to heating element 118 on and off.

[0080] Manual or timed operation of the device may be sufficient in some circumstances. However, in other implementations, the pump can be configured to operate at least partly in response to the temperature of water at various vertical positions being at, above, or below certain temperature thresholds.

[0081] For example, the device can be configured such that the pump operates at least partly in response to the temperature of water at a third vertical position being at or above a first predetermined threshold. The third vertical position can be at any suitable vertical height within the cylinder.

[0082] For example, the third vertical position can be at or below the first vertical position. In this configuration, the pump can be configured to only operate when there is water above a certain temperature available at the first level (i.e., allowing it to be extracted via the first conduit). The temperature threshold can be selected to suit the implementation and/or to take into account any necessary regulations. For example, it may be desirable to set the temperature threshold at the third vertical level near, but below, a temperature at which the heating element

will cut out. For example, if the heating element thermostat causes it to cut out at 65° C, the temperature threshold at the third vertical level can be set at 60° C. This approach ensures that hot water from the top of the cylinder will be moved lower in the cylinder by the device, ideally in time to ensure continued operation of the heating element.

[0083] Alternatively, or in addition, the device can be configured such that the pump operates at least partly in response to the temperature of water at a fourth vertical position being below a second predetermined threshold. The fourth vertical position can be any suitable vertical height within the cylinder.

[0084] For example, the fourth vertical position can be at or above the second vertical position 402. In this configuration, the pump can be configured to only operate when the water is below a certain temperature at (and/or above) the second vertical position 402 (i.e., at or above the outlet of the second conduit). The temperature threshold can be selected to suit the implementation and/or to take into account any necessary regulations. For example, it may be desirable to set the temperature threshold at the fourth vertical level near, but somewhat below the temperature at which the heating element will cut out. For example, if the heating element thermostat causes it to cut out at 65° C, the temperature threshold at the third vertical level can be set at 40° C.

[0085] Additional advantages may flow from using the temperatures at both the third and fourth vertical levels. For example, the pump can be configured to only operate when there is water above a certain temperature available at the first level (i.e., allowing it to be extracted via the first conduit) and the water is below a certain temperature at (and/or above) the second vertical position 402 (i.e., at or above the outlet of the second conduit). The temperature thresholds for the third and fourth vertical levels can be the same as described above.

[0086] For example, if the heating element thermostat is set to 65° C, it may be desirable to set the threshold at the third vertical level to 60° C, and the threshold at the fourth vertical level to 50° C.

[0087] The temperatures at one or more levels of the cylinder can be sensed in any suitable way. For example, one or more temperature sensors may be installed at or near each vertical level of interest. The temperature sensors can take the form of bimetallic or other relays that are designed to open/close at a particular threshold temperature. In that case, the temperature sensors can be connected in electrical series with the pump as described above.

[0088] Alternatively, the temperature sensors can take the form of thermal sensors designed to output a signal to a controller that can control whether the pump is turned on or off. For example, the or each temperature sensor can output a temperature signal to a controller by way of a wired or wireless connection. The temperature signal can take the form of a digital or analogue value representative of a temperature, or a binary signal indicating whether the

sensed temperature is above or below a particular threshold. Either way, the controller is configured to determine from the temperature signal(s) whether the pump should be turned on or off.

[0089] In alternative implementations, one or more of the temperature sensors can be installed for sensing the temperature at one or more levels within a hot water cylinder, for the purposes of, for example, controlling a remote primary heating source (such as a boiler, air source heat pump, etc.) and/or providing inputs to a controller associated with, for example, a home automation system, heating/cooling control system, an excess energy diverter such as that described above, and/or any other device and/or system other than the device. Any one or more of those systems can be used to control operation of the device without the need for the device to include its own temperature sensor(s).

[0090] Optionally, any or all of the thresholds can be modified to suit the implementation and/or to take into account any necessary regulations. The thresholds can be set by the installer, and/or changed by the user or operator, in order to optimize operation for the implementation and/or to adjust operation to suit the user's needs.

[0091] Figure 12 shows an example of an implementation in which device 202 comprises a first thermostat 242. First thermostat 242 can be installed against the wall of cylinder 200 (underneath any insulation, to improve speed and accuracy of temperature sensing). Alternatively, first thermostat 242 can be installed within a sealed pocket that extends into the interior of cylinder 200. This can increase speed and accuracy of temperature sensing, although this approach is only suitable where such a pocket already exists, or where it is cost effective to add one.

[0092] First thermostat 242 is closed (i.e., conducts current) when it senses a temperature above a threshold, and is open when it senses a temperature below that threshold. In some cases, first thermostat 242 may operate with some hysteresis.

[0093] First thermostat 242 is installed in a position that allows it to sense a temperature of water at a particular level of cylinder 200. For example, first thermostat 242 can be installed above a vertical position of heating element 118 within cylinder 200. This allows first thermostat 242 to determine when there is sufficient hot water within cylinder 200 to justify operation of device 202.

[0094] Electrically, first thermostat 242 is connected in series with power cord 210 connected to pump 230. This means that, when the temperature of cylinder 200 adjacent to first thermostat 242 reaches the threshold temperature, it closes, causing pump 230 to operate. Similarly, when the temperature of cylinder 200 adjacent to first thermostat 242 falls and reaches the threshold temperature again, it opens, causing pump 230 to stop. Optionally, a switch, timer, or other controller (not shown) can be connected in series or parallel with first thermostat 242.

[0095] The operation of first thermostat 242 will now be

described with reference to Figure 12. In Figure 12, the hot water within cylinder 200 has not yet reached the level of first thermostat 242. First thermostat 242 remains open, and pump 230 therefore remains off. Heating element 118 continues to heat water within cylinder 200, optionally as a result of excess power being devoted to it via a diverter as described above. Eventually, the hot water within cylinder 200 reaches the level of first thermostat 242, as shown by the position of line 122 in Figure 13. The temperature sensed by first thermostat 242 rises until it reaches the threshold, at which point first thermostat 242 closes, turning pump 230 on. Pump 230 operates in the manner described above, drawing hot water from the top of cylinder 200, and delivering it lower in the cylinder at the lower end of second conduit 206.

[0096] Pump 230 continues operating until the water within cylinder 200 adjacent first thermostat 242 drops in temperature sufficiently to cause first thermostat 242 reach the threshold temperature again. At that point, first thermostat 242 opens, causing pump 230 to stop operating. Cylinder 200 is now back at the state shown in Figure 12, and the process repeats for as long as heating element 118 continues to operate.

[0097] Eventually, all of the water within cylinder 200 may reach a sufficiently high temperature that first thermostat 242 no longer operates to turn pump 230. The temperature of the water around heating element 118 will continue to rise, until the thermostat of heating element 118 cuts in, stopping further heating of the water.

[0098] Since pump 230 in the implementation of Figures 12 and 13 is controlled solely by first thermostat 242, pump 230 will not turn off once there is no longer sufficient cold water within cylinder 200 to cause thermostat 242 to open. This may be acceptable in certain implementations. For example, where device 202 is designed to operate with an excess power diverter, pump 230 can be powered by the diverter such that it is only on while there is excess power being produced.

[0099] Alternatively, one or more additional controls may be put in place to reduce unnecessary running of pump 230. For example, some excess power diverters offer the option to control a relay for a destratification pump. Alternatively, or in addition, pump 230 can be partly controlled by a timer. For example, a timer (not shown) placed in series with power cord pump 230 may allow pump 230 to run for a predetermined time before switching off.

[0100] Figure 14 shows an alternative implementation of device 202. Device 202 has several features that are similar to those described in relation to the previously described implementations, and such features are indicated with like reference signs.

[0101] Device 202 includes a second thermostat 244. Second thermostat 244 can be installed against the wall of cylinder 200 (underneath any insulation, to improve speed and accuracy of temperature sensing). Alternatively, second thermostat 244 can be installed within a sealed pocket that extends into the interior of cylinder

200. This can increase speed and accuracy of temperature sensing, although this approach is only suitable where such a pocket already exists, or where it is cost effective to add one.

[0102] Second thermostat 244 is closed (i.e., conducts current) when it senses a temperature below a threshold, and is open when it senses a temperature above that threshold. As such, second thermostat 244 operates in the opposite sense to first thermostat 242. In some cases, second thermostat 244 may operate with some hysteresis.

[0103] Second thermostat 244 is installed in a position that allows it to sense a temperature of water at a particular level of cylinder 200. For example, second thermostat 244 can be installed above the vertical position of the lower end of the second conduit within cylinder 200. This allows second thermostat 244 to determine when device 202 can be turned off.

[0104] Electrically, second thermostat 244 is connected in series with the power cord 210 connected to pump 230. This means that pump 230 will only operate when the temperature of cylinder 200 adjacent to second thermostat 244 is below its threshold temperature. Optionally, a switch, timer, or other controller (not shown) can be connected in series or parallel with second thermostat 244.

[0105] The operation of second thermostat 244 will now be described with reference to Figure 14. In Figure 14, there is hot water in the upper end of cylinder 200, and the device 202 is operating due to having been switched on, for example manually, by way of a timer, or under the control of another control system. Hot water is being pumped from the first level 400 down to the second level 402, as described above in relation to other implementations.

[0106] Second thermostat 244 remains closed as a result of the adjacent water in cylinder 200 being below its threshold temperature.

[0107] Eventually, the hot water reaches the level of second thermostat 244, as shown in Figure 15. The rising temperature causes second thermostat to reach its threshold temperature, causing it to change to the open state. This turns pump 230 off, preventing it from continuing to operate. Second thermostat 244 will remain open until the temperature of the adjacent water within cylinder 200 falls sufficiently. The temperature may fall as a result of, for example, hot water being drawn off from cylinder 200 for use, and/or standing heat losses.

[0108] Figures 16 to 19 show an implementation of device 202 that uses both the first thermostat 242 and the second thermostat 244. In this implementation, the first thermostat 242 and second thermostat 244 are wired in series with each other and the power cord 210. This means that pump 230 will only operate while both the first thermostat 242 and the second thermostat 244 are in the closed state. This only happens when first thermostat 242 is above its temperature threshold and second thermostat 244 is below its temperature threshold.

[0109] In Figure 16, the heating element 118 is heating the water as described above in relation to other implementations. The hot water within cylinder 200, indicated by line 122, has not yet reached the level of first thermostat 242. First thermostat 242 is below its temperature threshold, and is therefore in the open state. The water adjacent to second thermostat 244 is relatively low in temperature. Second thermostat 244 is therefore below its temperature threshold and is therefore in the closed state. However, since first thermostat 242 is in the open state, pump 230 remains off.

[0110] Heating element 118 continues to heat water within cylinder 200, optionally as a result of excess power being diverted to it via a diverter as described above. Eventually, the hot water within cylinder 200 reaches the level of first thermostat 242, as shown in Figure 17. The temperature sensed by first thermostat 242 rises until it reaches its threshold, at which point first thermostat 242 closes, turning pump 230 on. Since both thermostats are now in the closed state, pump 230 operates in the manner described above, drawing hot water from the top of cylinder 200 through first conduit 204, and delivering at the lower end of second conduit 206.

[0111] Pump 230 continues operating until one of two things happens. A first possibility is that cooler water replacing the hot water extracted from the cylinder by the pump may cause the water within cylinder 200 adjacent first thermostat 242 to drop in temperature sufficiently to cause first thermostat 242 reach its threshold temperature again. This may happen as a design choice, or may be the result of, for example, the amount of power being delivered to the heating element being insufficient to keep up with the rate at which the pump is extracting hot water. If that happens, first thermostat 242 opens again, causing pump 230 to stop operating. Cylinder 200 is now back at the state shown in Figure 16, and the process repeats.

[0112] A second possibility is that the hot water within cylinder 200 reaches the level of second thermostat 244, as shown in Figure 19. In this case, the rising temperature of water within cylinder 200 adjacent to the second thermostat 244 will eventually cause second thermostat 244 to reach its temperature threshold and open, causing pump 232 to switch off. Second thermostat 244 will remain open until the temperature of the adjacent water within cylinder 200 falls sufficiently. The temperature may fall as a result of, for example, hot water being drawn off from cylinder 200 for use, and/or standing heat losses.

[0113] Once the temperature of the adjacent water within cylinder 200 falls such that second thermostat 244 reaches its temperature threshold again, second thermostat 244 closes. Assuming the temperature of first thermostat 242 at that time is above its temperature threshold (and hence it is in the closed state), then pump 230 will start operating again.

[0114] An alternative embodiment of a device 202 is shown in Figure 20. In device 202, the first and second T-connectors are replaced by a four-way connector 500,

having two adjacent 22 mm compression joints, a 15mm compression joint and a 10 mm compression joint.

[0115] A first of the 22 mm compression joints connects to the hot water cylinder 200, for example as described above. The other of the 22 mm compression joints connects horizontally to a 22 mm pipe that leads to the rest of the hot water plumbing.

[0116] The second conduit 206 passes upwards through BSP connection 110, through the centre of connector 500, and is joined to the 10 mm compression joint on the connector 500 opposite cylinder 200. Second conduit 206 bends in a single piece around to connect to the outlet of pump 230. Having second conduit 206 connect to pump 230 without joins reduces the amount of work required for installation, as well as reducing leakage risks (which can be of greater concern when forming joints with annealed copper pipe). Nevertheless, in other implementations, any suitable components, including connectors such as elbows, can be used to connect second conduit 206 to pump 230.

[0117] Pipe 236 is connected between the 15 mm compression joint on connector 500 and inlet 232 of pump 230, using a 15-10mm reducer (not shown) at the 15 mm compression joint.

[0118] In use, device 202 of Figure 20 operates in substantially the same manner as that of Figure 6. An advantage of device 202 using a T-connector, such as connector 500, is that the physical relationship between the two 22 mm compression joints is similar to the relationship between the compression joints on a standard 22 mm elbow. This means that the four-way connector 500 can directly connect to the existing connection at the cylinder outlet and to existing horizontal pipework, where an existing installation uses a 22 mm elbow in this position. Similar comments apply to other standard sizes of connectors and T-pieces that may be used to replace existing elbows in other installations.

[0119] Another potential advantage of the device shown in Figure 20 is that it is more compact and has a smaller number of parts to assemble. It is therefore cheaper to produce.

[0120] The implementations described above use some standard copper and/or brass plumbing components. In some cases, those components may require modification. Example, where a reducing connector such as second T-connector 218 is used, it may be necessary to remove or modify the connector or a component of the connector (including, for example, an internal bushing of the connector) to allow the second conduit to pass through the connector.

[0121] Where copper or brass plumbing components are used, any suitable form and combination of connections, connectors, and fittings can be used to construct the first and second conduits, and any connections between the conduits and pump. Different sizes, including metric, imperial, other standards, and non-standard sizes may be used. Reducers, adaptors, and other devices may be used to ensure compatibility between the device

and the tank and other pipework to which it is to be connected. For example, since 22 x 22 x 15 x 10 compression joint cross connector is not a commonly available standard part, a 22 x 22 x 15 x 15 compression joint cross connector can be used with a 15-10 reducer on the 15 mm compression joints. Other sizes and type of reducers and adapters will suggest themselves to the skilled person.

[0122] In addition, all conduits and other elements can be joined in any suitable manner, including soldering, compression fittings, threaded fittings, flange fittings, push-fit, solvent weld, and any other suitable type of fitting or joint type.

[0123] Where allowed by local regulations, some of the conduits and/or other components can be formed from polymer materials.

[0124] In other implementations, the device can be formed from non-standard, purpose-manufactured components.

[0125] Although the implementations described above show the second conduit passing coaxially with the first conduit, this need not be the case. For example, the first conduit and second conduit can be positioned side-by-side. In that case, a mounting body may be provided. The first and second conduits pass through the body, which supports them and provides a means for connecting the conduits to hot water cylinder.

[0126] Alternatively, or in addition, two or more first conduits, and/or two or more second conduits can be used. This may be of particular use where the conduits are circular in cross-section, and positioned side-by-side, as it increases the total cross-sectional area of the conduits for a given aperture size.

[0127] Although not shown in any of the drawings, one or more manual or automatic air vents can be installed at any suitable point in device 202 or the surrounding pipework in order to allow venting of air that may become trapped during operation.

[0128] Where one or more thermostats are used, the operating temperature(s) can optionally be variable, so that, as described above, any or all of the thresholds can be modified to suit the implementation and/or to take into account any necessary regulations. The thresholds can be set by the installer, and/or changed by the user or operator, in order to optimize operation for the implementation and/or to adjust operation to suit the user's needs or preferences. Similarly, if the cut-off temperature of the heating element is adjustable, this can be adjusted in conjunction with the thresholds of the other thermostat(s) by the user or installer in order to suit the user's needs or preferences.

[0129] The implementations described above are configured to maintain stratification within the cylinder. This can be achieved by any suitable combination of factors such as pump flow rate, and the speed and direction of the water exiting the lower end of second conduit 206.

[0130] For example, any of the implementations above can increase the pump speed to increase the rate at

which the hot water exits the lower end of second conduit 206. The higher exit speed will tend to increase mixing of the hot water with the cooler surrounding water around the bottom of second conduit 206. This reduces buoyancy and hence can reduce or even prevent stratification due to the water rising within cylinder 200. In some implementations, it may be necessary to use a higher power pump to enable sufficient flow speed to reduce or prevent stratification.

[0131] Optionally, the lower end of conduit 206 can be shaped or otherwise modified to increase speed and/or turbulence of water exiting it. For example, the lower end of conduit 206 can be partly crimped or bent to some angle other than directly downwards. Alternatively, or in addition, an outlet attachment can be attached to the lower end of second conduit 206 to increase the speed and/or turbulence of the exiting water. For example, an end piece with one or more features such as holes or turbulating features, such as horizontally directed holes and/or vanes that turbulate the exiting water, can be attached to the lower end of conduit 206. At lower pump speeds, such arrangements can still cause low enough mixing that they are able to generate a convection current that allows for the maintenance of stratification. At higher pump speeds, the increased speed of the water causes increased mixing, which reduces buoyancy, optionally to the point where little to no stratification takes place.

[0132] In any particular implementation, a (low-speed) stratifying or (high-speed) non-stratifying configuration can be used. Optionally, the pump speed is switchable so as to enable the user to control which configuration is in operation at any given time.

[0133] Referring now to Figure 21, there is shown a method 600 of fitting a device, such as any of the previously described devices, to a hot water cylinder.

[0134] The cylinder is optionally prepared 602 for installation of the device by removing any existing hot water connection from the top of the cylinder. When retrofitting to an existing cylinder, this preparation may also need to account for any changes needed to refit the hot water connection after the device has been fitted. For example, the existing hot water pipework may need to have its position adjusted (e.g., lowered or raised). Where the installation is to a new water cylinder, such preparation may not be needed. For example, the device may be factory-fitted, or fitted on-site before connection of the cylinder to the hot water plumbing.

[0135] The result of the preparation step 602, if needed, is that the aperture on top of the cylinder is open, and a suitable connector, such as a BSP to compression joint connector is installed if needed.

[0136] Optionally, the second conduit is adjusted 606 by bending, shaping, and/or trimming at least part of the second conduit along its length so as to adapt the device to the hot water cylinder to which it is to be installed. For example, the device may be provided with a standard length of second conduit that can be adapted to suit cylinders of different heights. This may require trimming

of the second conduit so that it does not extend too far down into the particular cylinder to which the device is to be installed. Similarly, in certain circumstances it may be decided to only extend the second conduit part of the way into the cylinder, such as 50% or 70% of the way down into the cylinder. This may be done for any suitable reason, including, for example, adapting the length of the conduit to an existing thermostat installation point(s).

[0137] Alternatively, or in addition, the second conduit may be bent or shaped as required. For example, if the second conduit is only slightly too long, it may be sufficient to work a slight bend into it in order to shorten it so that it terminates at the correct second vertical position, thereby avoiding trimming. It may also be desirable to adjust the shape of the second conduit in order to ensure it does not foul on, for example, any internal heating coil or heating element.

[0138] Such bending and shaping can be more convenient if the second conduit is formed from a plastically deformable material. For example, standard un-annealed copper piping may be too rigid to easily form by hand, and due to its stiffness is more likely to kink if bent by hand. Accordingly, forming the second conduit, or at least any portion that is likely to need bending or shaping, from a plastically deformable material, such as annealed copper, may assist in the bending and shaping process.

[0139] Next, at least a portion of the second conduit is inserted 608 through the aperture. The second conduit is fed through the aperture until the lower portion of the first conduit reaches the connector at the aperture. The lower portion of the first conduit includes a connector that matches the connector on the cylinder.

[0140] The device is then attached 610 to the hot water cylinder. For example, if the connector on the cylinder terminates in a compression joint, then a short length of pipe can be used to connect the device to the compression joint.

[0141] The pump can be connected to a suitable power source. Optionally, the connection can be via one or more temperature sensors or thermostats, as described in more detail above. Such temperature sensors may already be installed on the cylinder, or can be installed as part of the process of installing the device.

[0142] In some cases, access to the aperture is constrained. For example, if the cylinder is in a cupboard, there may be limited vertical access above the aperture at the top of the cylinder. In that case, the second conduit can be bent into a shape that allows it to be threaded into the cylinder at an angle. If necessary, the second conduit can be re-bent into a straighter configuration as it is fed into the cylinder, and/or adjusted when it is nearly entirely within the cylinder.

[0143] The device may be suitable for any hot water storage tank (not just hot water cylinders which are exemplified above). As such, where the context allows, any reference to a hot water cylinder may be considered as referring to a hot water storage tank (e.g. of any size or shape). Further, in any such device (in relation to hot

water cylinders or hot water storage tanks more generally), the device may be arranged such that the pump is arranged in reverse or capable of being operated in the reverse direction, whereby water may be drawn from the second conduit, which may have a vertical position lower than the first conduit, and returned through the first conduit.

[0144] The device of the third aspect may optionally, where the context allows, be as further defined by the preferred implementations described above.

[0145] The device of the first or third aspects, in any particular implementation described above as may be appropriate, finds application in central heating systems, for example for use in one or more buffer tanks of a central heating system. As such, a conventional central heating circuit (e.g. in a vented system) feeding one or more radiators may have a flow pipe from a heating source (e.g. a boiler or a heat pump arrangement) serving a radiator arrangement and a return pipe which serves to return cooled water from the radiator arrangement back to the heating source. The return pipe may feed into a hot water storage tank (or cylinder), e.g. through the first or second conduit, preferably the second conduit which is preferably configured to deliver return flow water to a lower portion of the hot water storage tank and a further return pipe configured to draw water from the hot water storage tank, e.g. through the other of the first or second conduit, preferably the first conduit which is preferably configured to draw return flow water from an upper portion of the hot water storage tank. The further return pipe may optionally then feed into a second hot water storage tank in the same way as the first hot water storage tank. There may be two, three, four or more hot water storage tanks arranged in series with further return pipes drawing hot water. From the upper portion of each and feeding the next and a final return pipe returning the return flow water to the heat source. Each hot water storage tank may be heated by any suitable heat source, but typically a heating element or immersion heater, optionally in an upper portion thereof (e.g. to retain stratification) and a device as defined above configured to maximise the heat storage capacity of the hot water storage tank. In one embodiment, the one or series of hot water storage tanks is the heating source for the central heating system and the final outlet from the last tank in the series is the flow pipe.

[0146] Further aspects and/or embodiments of the invention are described in the following clauses:

Clause 1. A device for installation through an outlet of a hot water cylinder, the outlet defining an aperture into the hot water cylinder, the device comprising:

- a first conduit configured to allow water to be extracted from the hot water cylinder through the aperture, at a first vertical position relative to the hot water cylinder;
- a second conduit configured to pass through the

aperture and to return the extracted water to the hot water cylinder, the second conduit being configured to terminate within the hot water cylinder at a second vertical position within the hot water cylinder, the second vertical position being lower than the first vertical position; and a pump, to be positioned, in use, external to the hot water cylinder, the pump having an inlet in fluid communication with the first conduit and an outlet in fluid communication with the second conduit, the device being configured such that, when installed through the aperture of a hot water cylinder and the pump is operating, water is extracted by the pump from the hot water cylinder through the first conduit, and returned by the pump to the hot water cylinder through the second conduit, thereby to transfer the water extracted by the pump to a lower portion of the cylinder where the second conduit terminates.

Clause 2. The device of clause 1, wherein the second conduit is coaxial with the first conduit over at least a portion of the length of each of the first and second conduits.

Clause 3. The device of clause 2, wherein the second conduit extends within the first conduit over at least a portion of the length of each of the first and second conduits.

Clause 4. The device of clause 2 or clause 3, wherein the first conduit comprises a vertically extending portion, the second conduit exiting the first conduit at an upper end of the vertically extending portion.

Clause 5. The device of any one of clauses 2 to 4, wherein the first conduit comprises a horizontal branching portion, the inlet of the pump being fluidly connected to the horizontal branching portion.

Clause 6. The device of any preceding clause, wherein the second conduit is configured to extend at least 0.5 m into the hot water cylinder from the aperture.

Clause 7. The device of clause 6, wherein the second conduit is at least 1 m long.

Clause 8. The device of clause 7, wherein the second conduit is trimmable at the point of installation, such that the second vertical position is at a desired distance from a bottom and/or top of the hot water cylinder.

Clause 9. The device of any preceding clause, wherein the second conduit is formed from a plastically deformable material, thereby allowing it to be

bent to a desired shape before installation onto a hot water cylinder.

Clause 10. The device of clause 9, wherein the second conduit is at least partly formed from annealed copper. 5

Clause 11. The device of any preceding clause, wherein an outer diameter of the second conduit is less than 12 mm. 10

Clause 12. The device of clause 11, wherein an outer diameter of the second conduit is 10 mm or less.

Clause 13. The device of any preceding clause, wherein the pump has a capacity of 6 litres/minute or less. 15

Clause 14. The device of any preceding clause, configured such that the pump operates at least partly in response to the temperature of water at a third vertical position being at or above a first predetermined threshold. 20

Clause 15. The device of clause 14, wherein the third vertical position is at or below the first vertical position. 25

Clause 16. The device of any preceding clause, configured such that the pump operates at least partly in response to the temperature of water at a fourth vertical position being below a second predetermined threshold. 30

Clause 17. The device of clause 16, wherein the fourth vertical position is at or above the second vertical position. 35

Clause 18. The device of any preceding clause, comprising at least one temperature sensor and/or thermostat for sensing a temperature of the hot water cylinder, and/or water within the hot water cylinder, at at least one vertical level of the hot water cylinder, for use in controlling the pump. 40

Clause 19. A hot water cylinder comprising the device of any preceding clause. 45

Clause 20. A method of retrofitting the device of any one of clauses 1 to 18 to a hot water cylinder, the method comprising: 50

inserting at least a portion of the second conduit through the aperture such that a lower end of the second conduit terminates at the second level; and
attaching the device to the hot water cylinder. 55

Clause 21. The method of clause 20, comprising: prior to inserting the portion of the second conduit through the aperture, bending, shaping, and/or trimming at least part of the second conduit along its length so as to adapt the device to the hot water cylinder to which it is to be installed.

Clause 22. The method of clause 20 or 21, comprising:

prior to inserting the portion of the second conduit through the aperture, bending and/or shaping the second conduit to enable it to be inserted through the aperture while avoiding any obstacles;
after inserting at least some of the portion of the second conduit through the aperture, bending and/or shaping the second conduit again, so as to adapt the device to the hot water cylinder to which it is to be installed.

[0147] Although the invention has been described with reference to a number of aspects, examples and alternatives, the skilled person will appreciate that the invention may be embodied in many other forms.

Claims

1. A device for installation through an outlet of a hot water storage tank, the outlet defining an aperture into the hot water storage tank, the device comprising:

a first conduit configured to allow water to be extracted from the hot water storage tank through the aperture, at a first vertical position relative to the hot water storage tank;

a second conduit configured to pass through the aperture and to return the extracted water to the hot water storage tank, the second conduit being configured to terminate within the hot water storage tank at a second vertical position within the hot water storage tank, the second vertical position being lower than the first vertical position, or, in the alternative, higher than the first vertical position; and

a pump, to be positioned, in use, external to the hot water storage tank, the pump having an inlet in fluid communication with the first conduit and an outlet in fluid communication with the second conduit or *vice versa*,

the device being configured such that, when installed through the aperture of a hot water storage tank and the pump is operating, water is extracted by the pump from the hot water storage tank through the first conduit, and returned by the pump to the hot water storage tank

through the second conduit, or *vice versa*, thereby to transfer the water extracted by the pump to a lower portion (or higher portion, if so arranged) of the tank where the second conduit terminates or, in the alternative, to a higher portion (or lower portion, if so arranged) of the tank where the first conduit terminates

and wherein the hot water storage tank is optionally a hot water cylinder.

2. The device of claim 1, wherein the second conduit is coaxial with the first conduit over at least a portion of the length of each of the first and second conduits.

3. The device of claim 2, wherein the second conduit extends within the first conduit over at least a portion of the length of each of the first and second conduits.

4. The device of claim 2 or claim 3, wherein the first conduit comprises a vertically extending portion, the second conduit exiting the first conduit at an upper end of the vertically extending portion.

5. The device of any one of claims 2 to 4, wherein the first conduit comprises a horizontal branching portion, the inlet of the pump being fluidly connected to the horizontal branching portion.

6. The device of any preceding claim, wherein the second conduit is configured to extend at least 0.5 m into the hot water storage tank from the aperture and preferably wherein the second conduit is at least 1 m long.

7. The device of any preceding claim, wherein the second conduit is formed from a plastically deformable material, thereby allowing it to be bent to a desired shape before installation onto a hot water storage tank and is preferably at least partly formed from annealed copper.

8. The device of any preceding claim, wherein an outer diameter of the second conduit is less than 12 mm, preferably is 10 mm or less.

9. The device of any preceding claim, wherein the pump has a capacity of 6 litres/minute or less.

10. The device of any preceding claim, configured such that the pump operates at least partly in response to the temperature of water at a third vertical position being at or above a first predetermined threshold and preferably wherein the third vertical position is at or below the first vertical position.

11. The device of any preceding claim, configured such that the pump operates at least partly in response to

the temperature of water at a fourth vertical position being below a second predetermined threshold, and preferably wherein the fourth vertical position is at or above the second vertical position.

12. The device of any preceding claim, comprising at least one temperature sensor and/or thermostat for sensing a temperature of the hot water storage tank, and/or water within the hot water storage tank, at at least one vertical level of the hot water storage tank, for use in controlling the pump.

13. A hot water storage tank comprising the device of any preceding claim.

14. A method of retrofitting the device of any one of claims 1 to 12 to a hot water storage tank, the method comprising:

inserting at least a portion of the second conduit through the aperture such that a lower end of the second conduit terminates at the second level; and
attaching the device to the hot water storage tank and, optionally,
prior to inserting the portion of the second conduit through the aperture, bending, shaping, and/or trimming at least part of the second conduit along its length so as to adapt the device to the hot water storage tank to which it is to be installed.

15. The method of claim 14, comprising:

prior to inserting the portion of the second conduit through the aperture, bending and/or shaping the second conduit to enable it to be inserted through the aperture while avoiding any obstacles;
after inserting at least some of the portion of the second conduit through the aperture, bending and/or shaping the second conduit again, so as to adapt the device to the hot water storage tank to which it is to be installed.

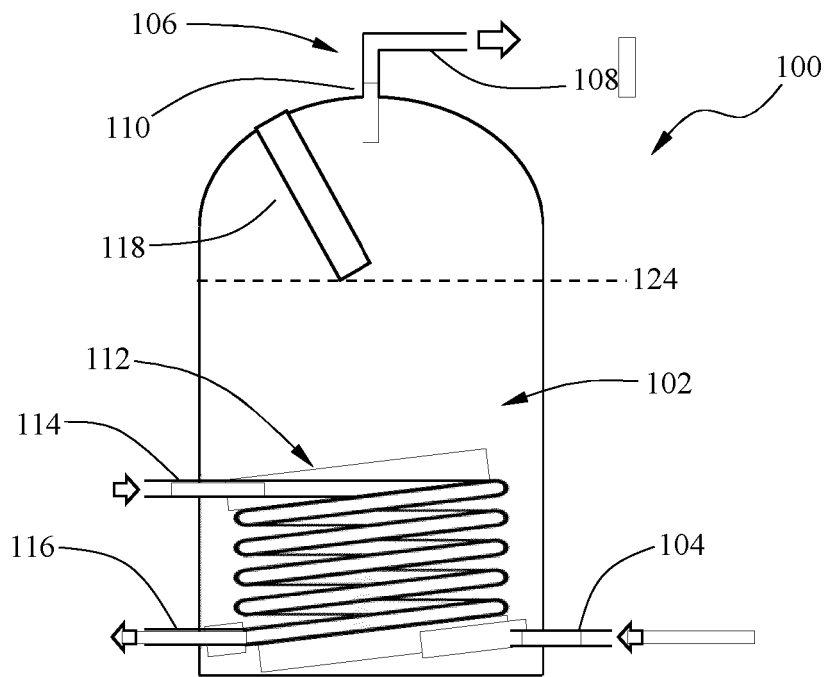


Figure 1

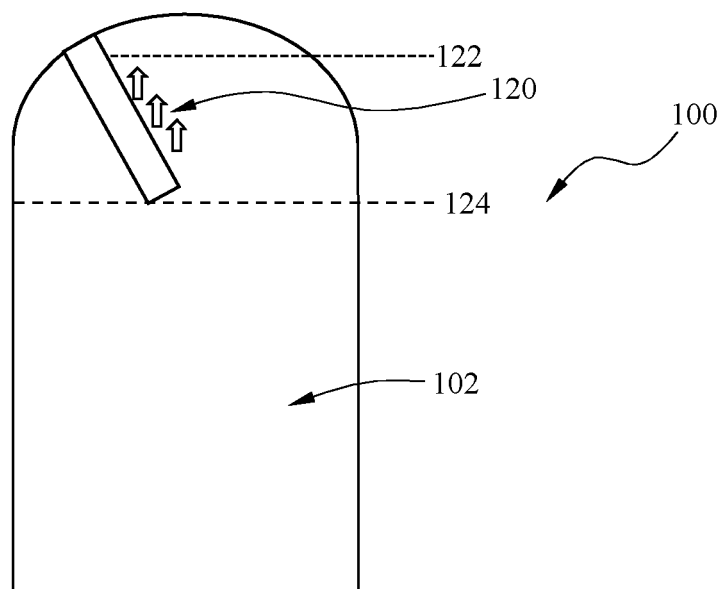


Figure 2

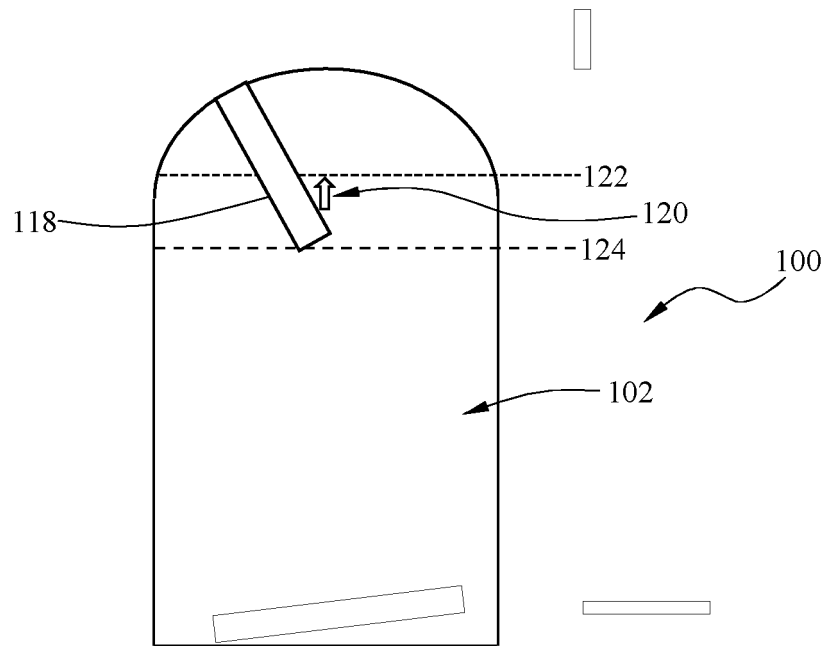


Figure 3

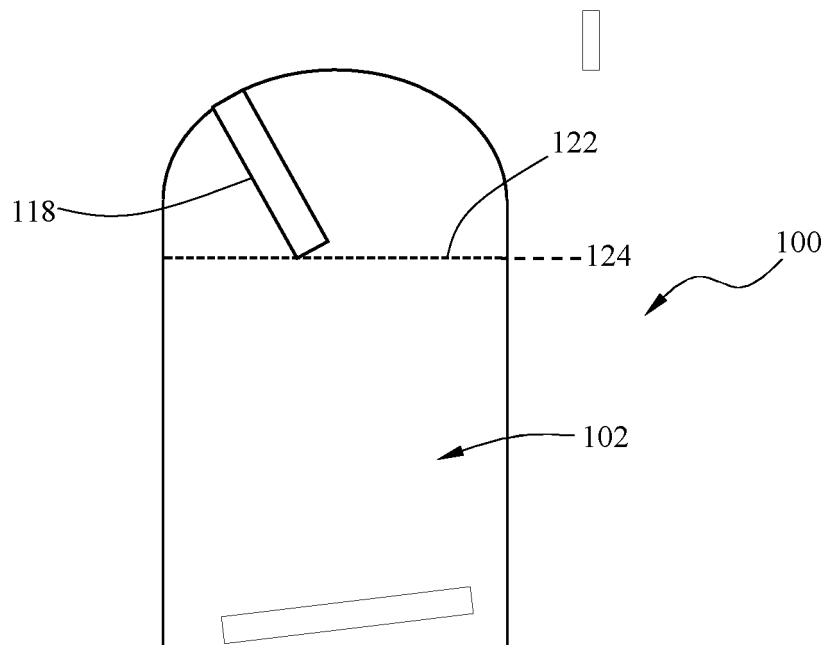


Figure 4

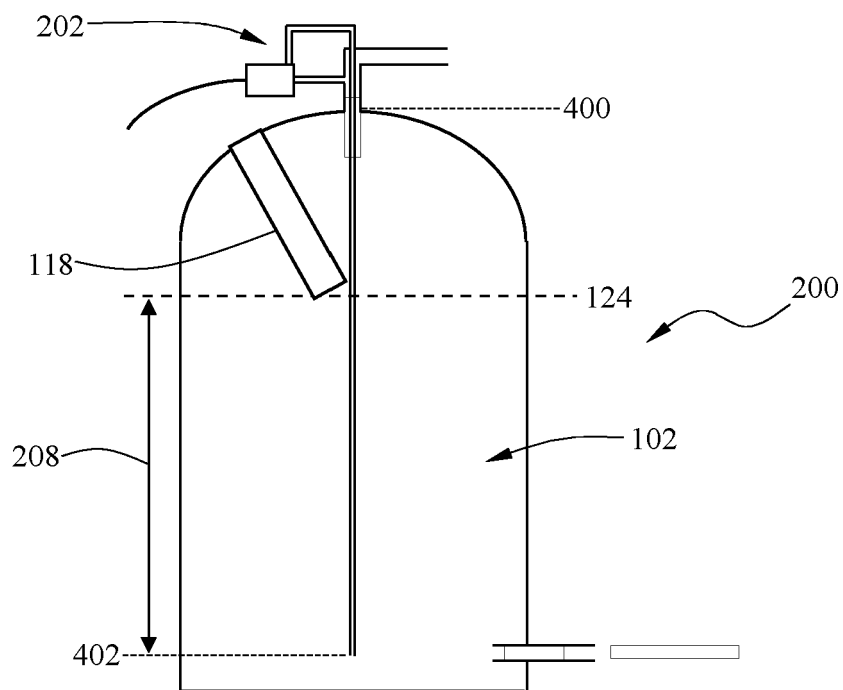


Figure 5

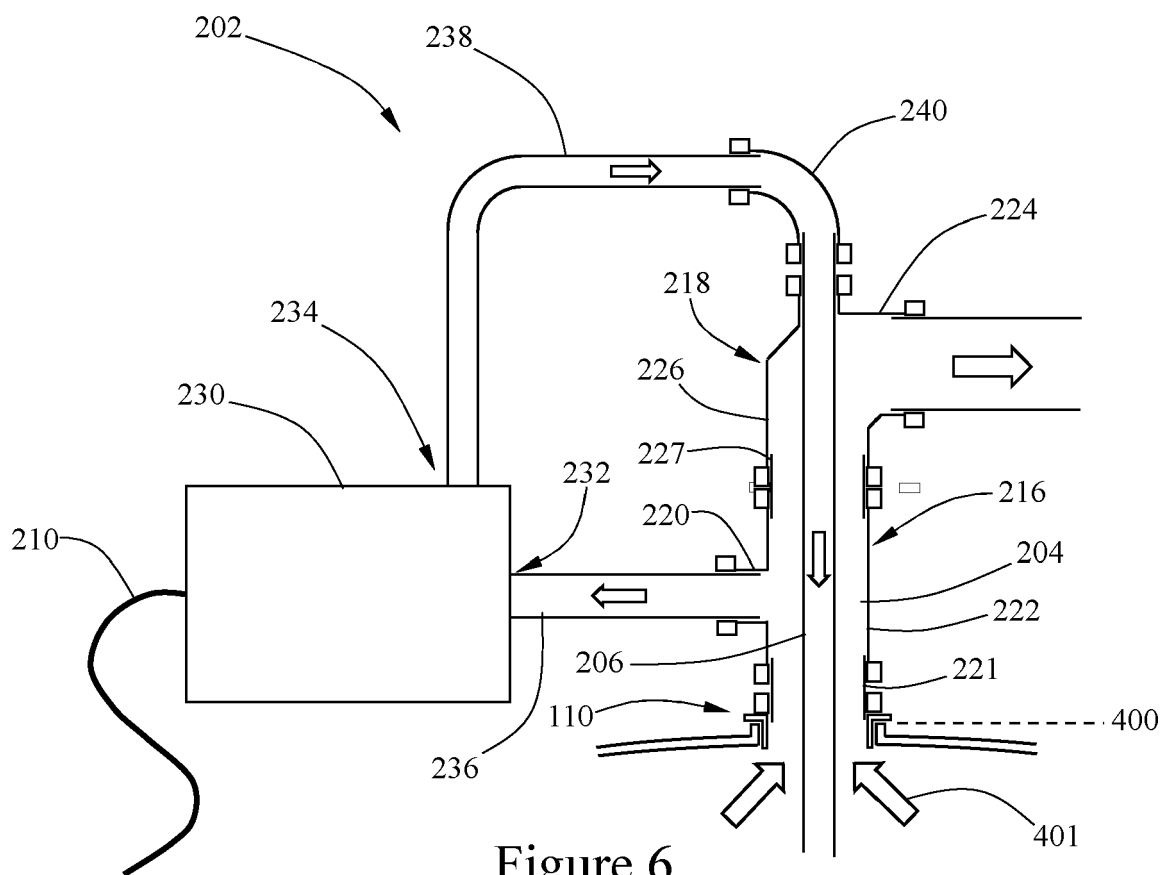


Figure 6

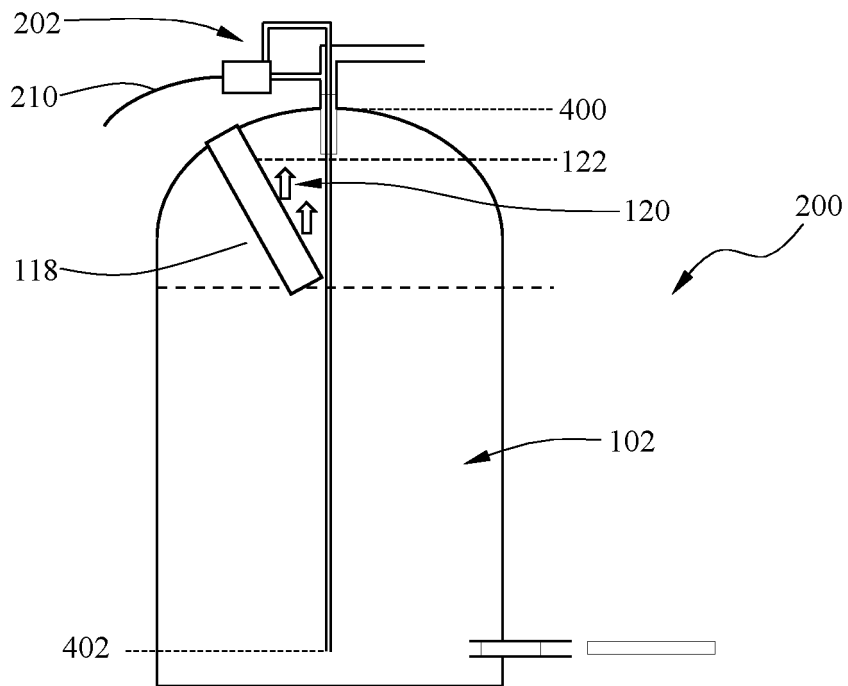


Figure 7

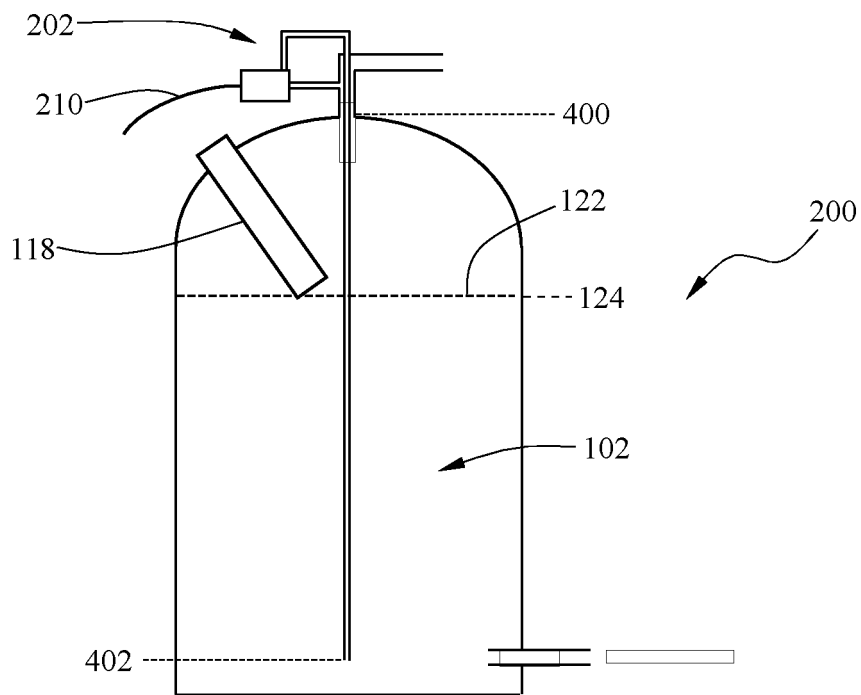


Figure 8

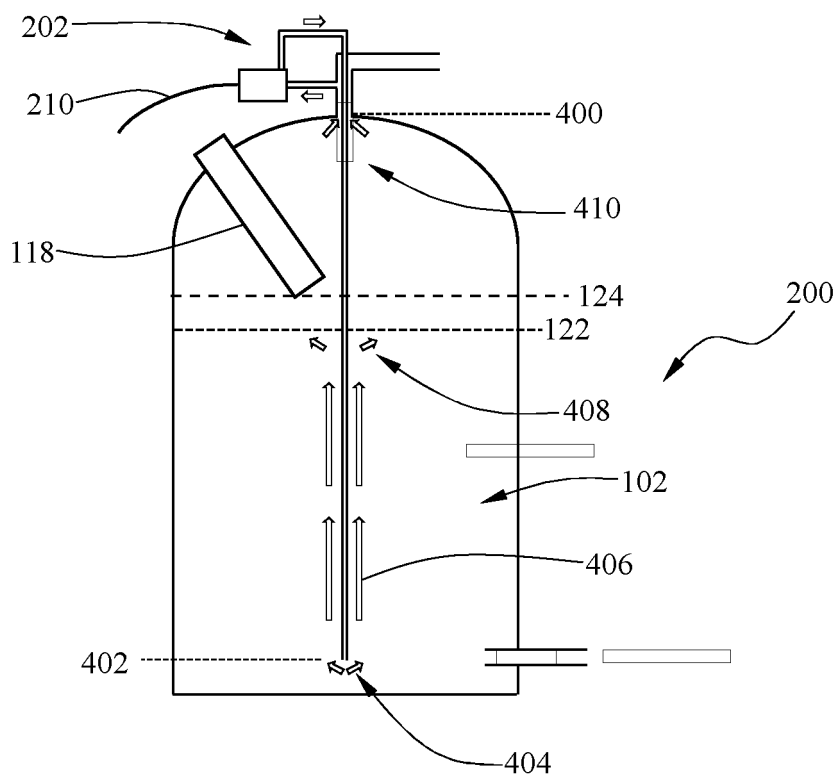


Figure 9

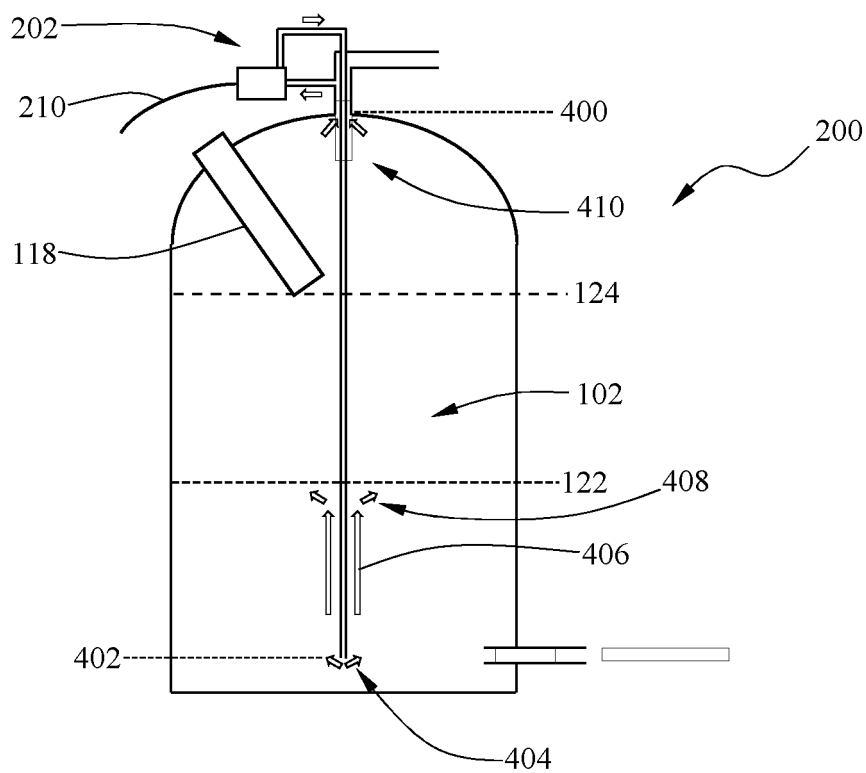


Figure 10

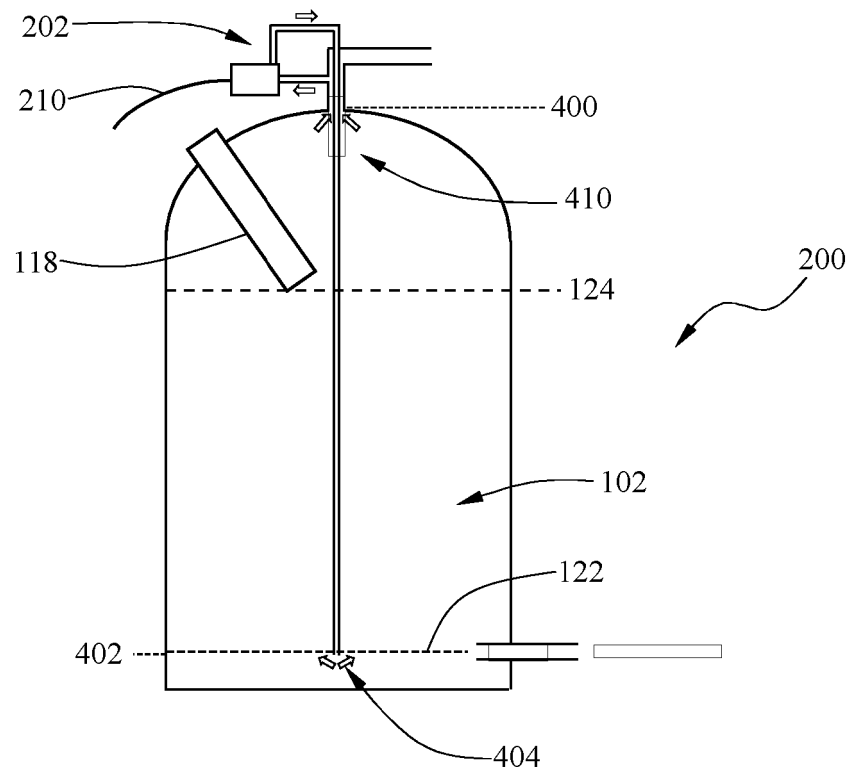


Figure 11

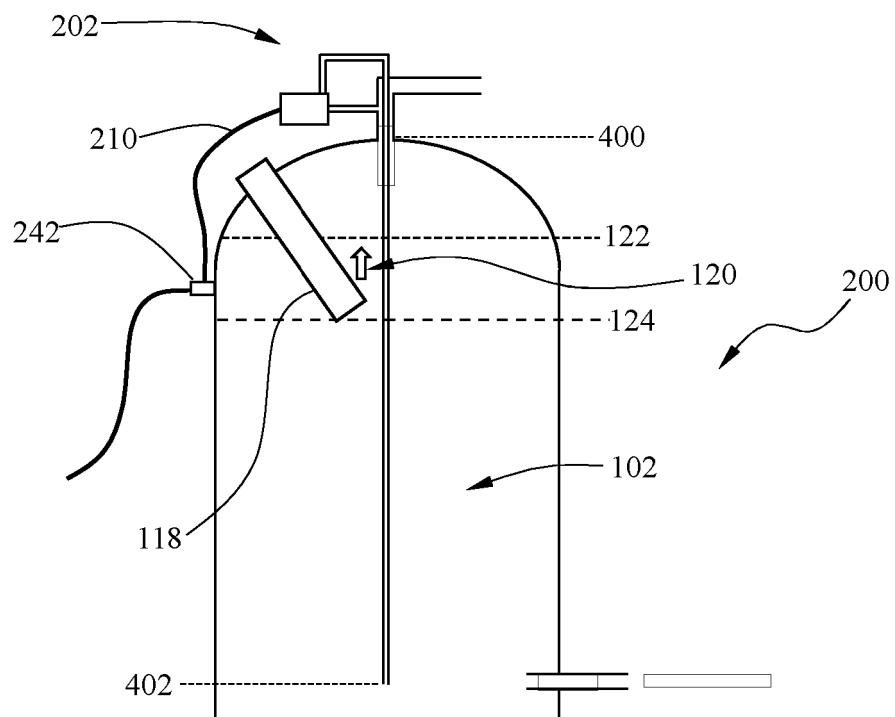


Figure 12

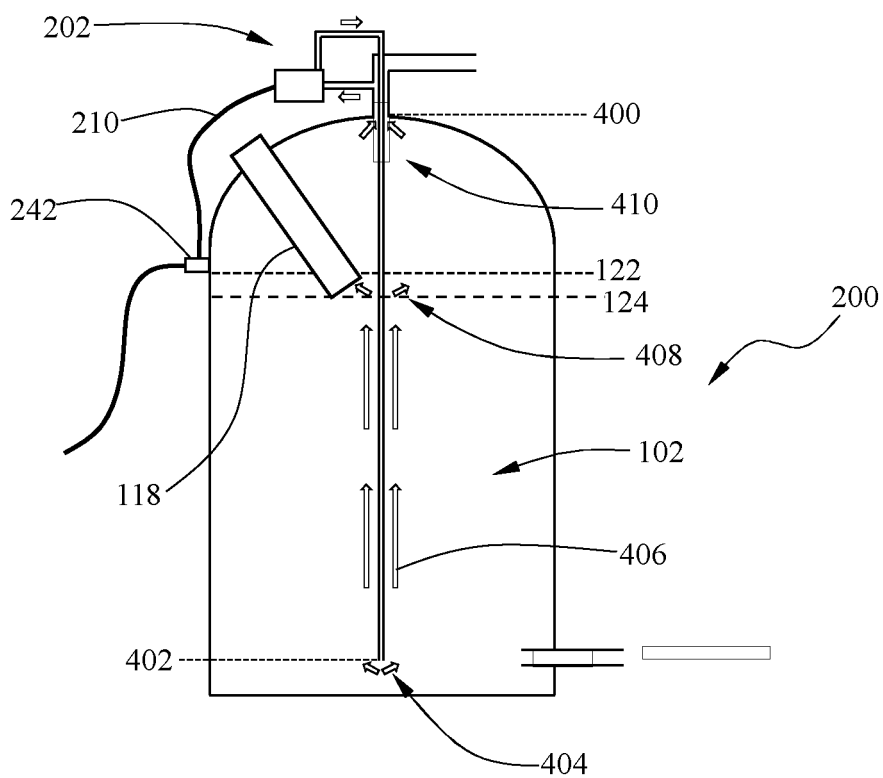


Figure 13

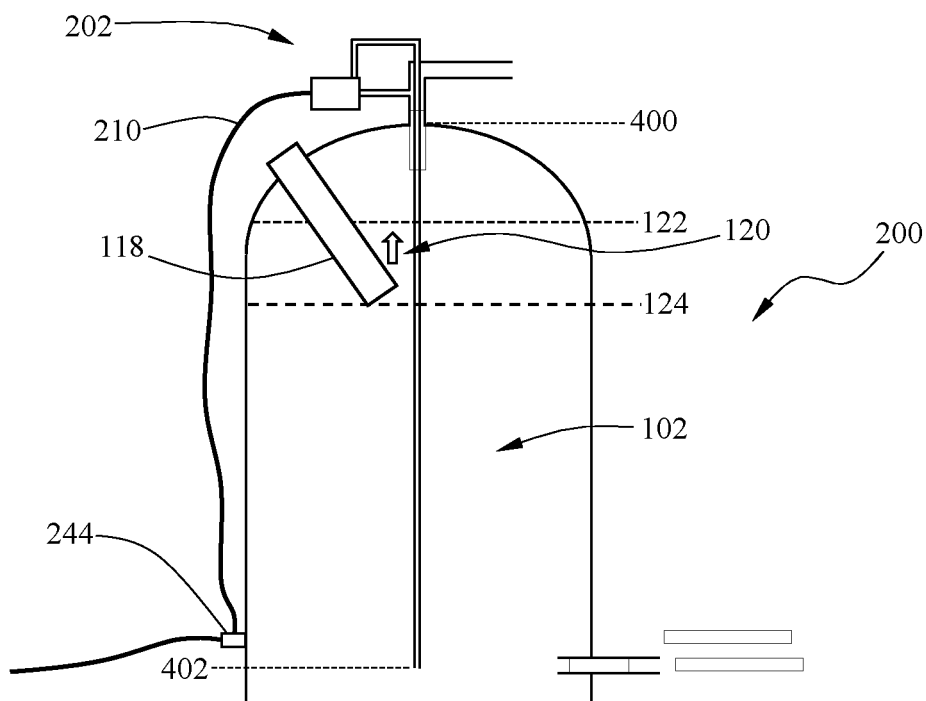


Figure 14

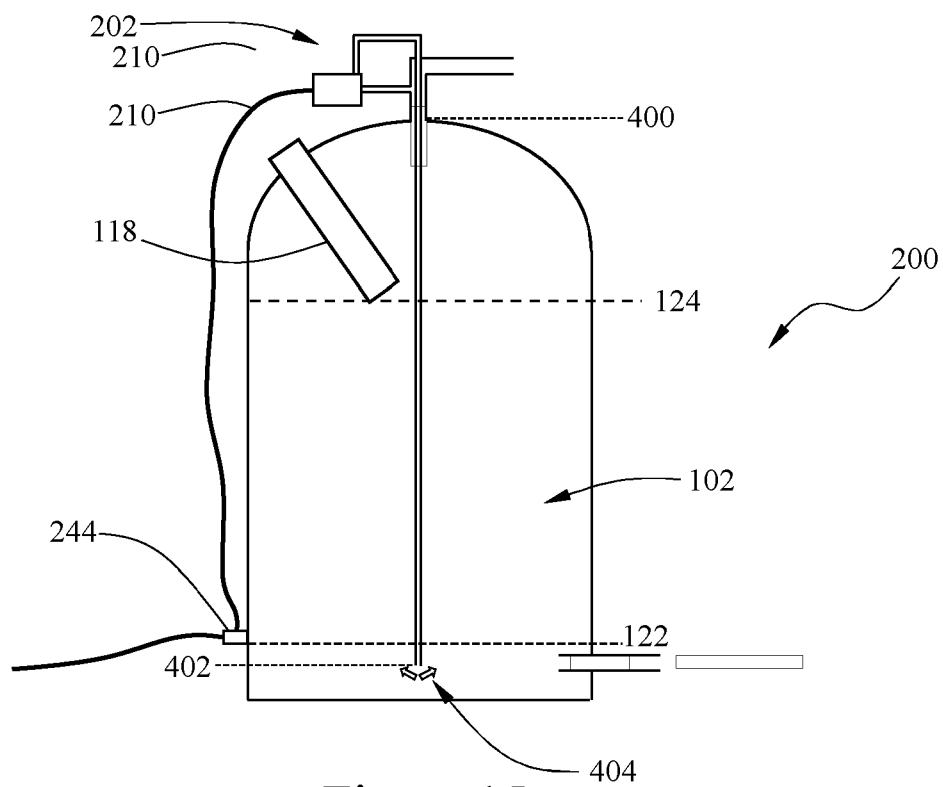


Figure 15

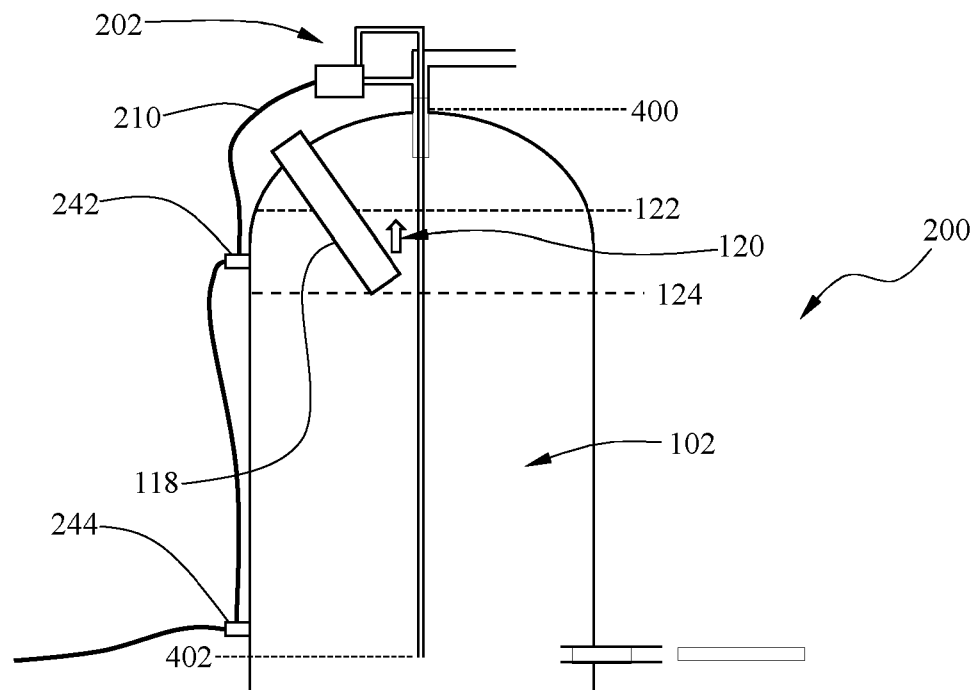


Figure 16

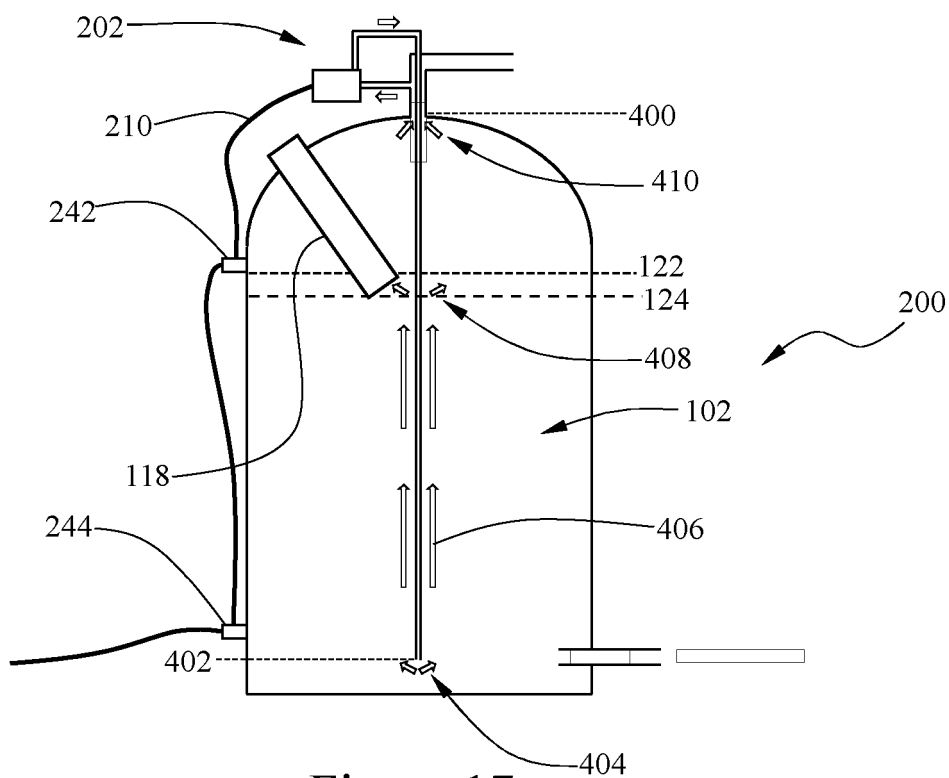


Figure 17

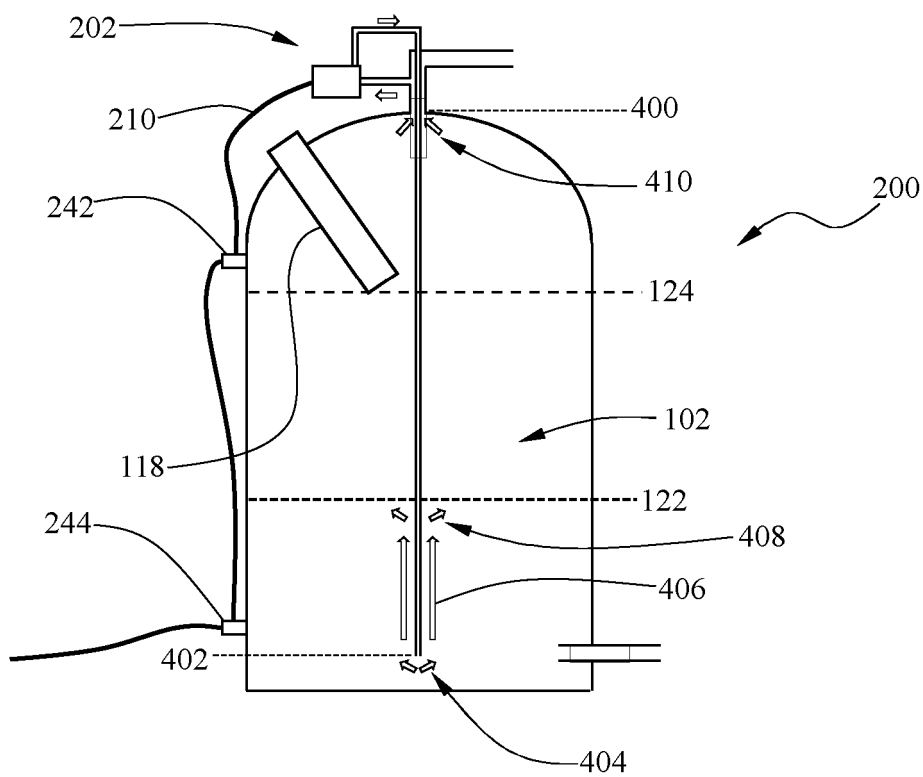


Figure 18

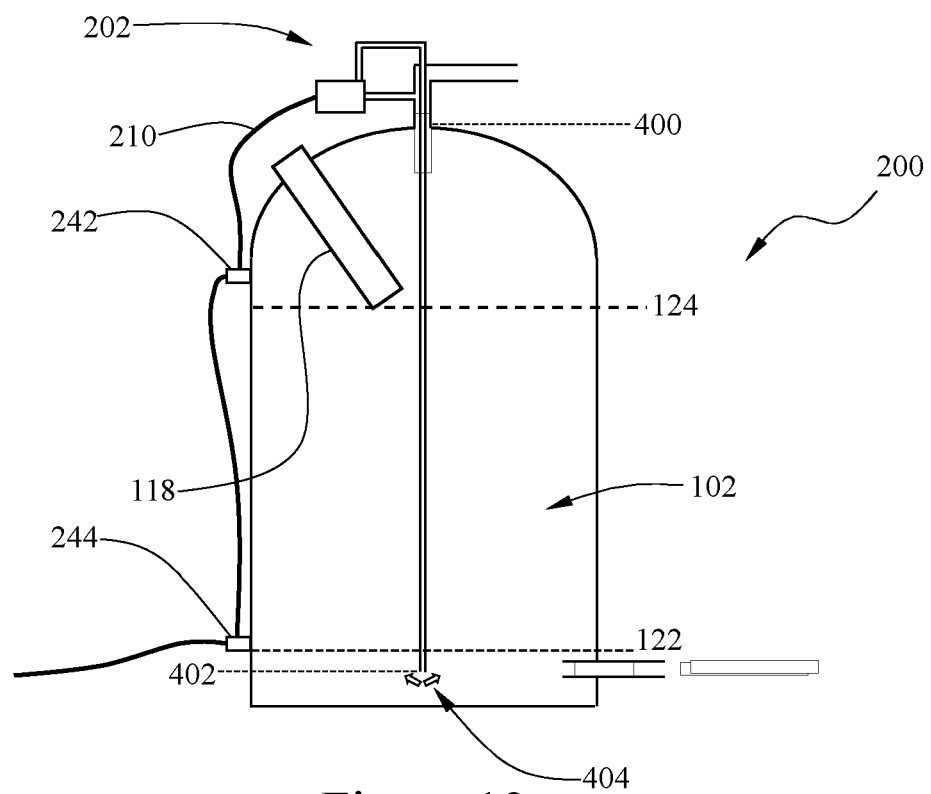


Figure 19

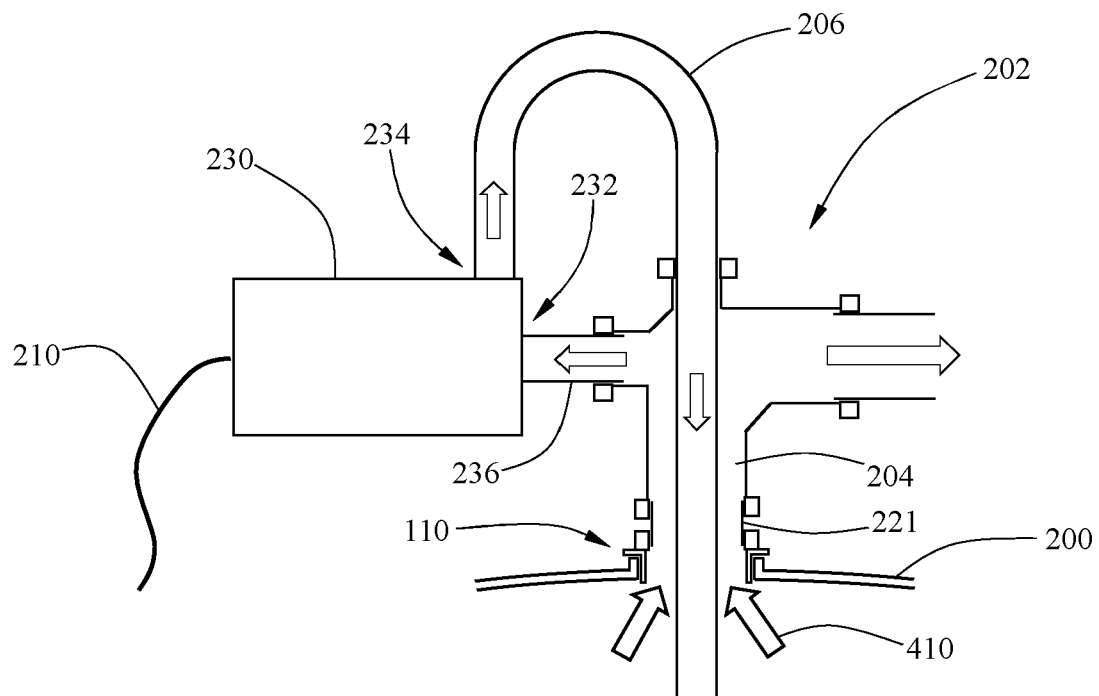


Figure 20

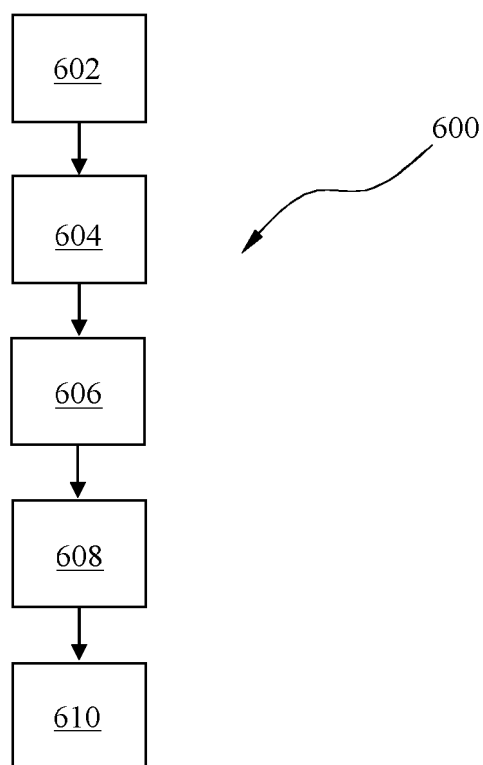


Figure 21



EUROPEAN SEARCH REPORT

Application Number

EP 24 20 6280

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2016/003830 A1 (HAWS SPENCER K [US]) 7 January 2016 (2016-01-07) * paragraphs [0020] - [0042]; figures 4a,16,18a,18b *	1-15	INV. F24H9/20 ADD. F24D17/00
X	CA 2 963 891 A1 (MICLAU SRI INC [CA]) 7 October 2018 (2018-10-07) * paragraphs [0016] - [0026]; figure 1 *	1-15	
X	US 4 682 581 A (LAING KARSTEN [US] ET AL) 28 July 1987 (1987-07-28) * column 1, line 11 - column 2, line 12; claims 1-4; figures 1-2 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F24H F24D
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		11 February 2025	Hoffmann, Stéphanie
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EP 24 20 6280

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016003830 A1	07-01-2016	US 2015377497 A1	31-12-2015
		US 2019234622 A1	01-08-2019
		WO 2016003830 A1	07-01-2016

CA 2963891 A1	07-10-2018	NONE	

US 4682581 A	28-07-1987	NONE	

EPO FORM P0459

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