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(54) **WATER CIRCULATION MODULE AND HOT WATER SYSTEM USING THE SAME**

(57) The present invention discloses a water circulation module adapted to be installed in a hot water system including a water heating appliance having an water inlet and a water outlet, a cold water pipeline in communication with the water inlet, and a hot water pipeline in communication with the water outlet. The water circulation module is disposed outside the water heating appliance and connected between the hot water pipeline and the cold water pipeline, so as to selectively establish a water circulation path between itself and the water heating appliance and thereby heating cold water in the water

circulation path. The water circulation module includes a main waterway, a temperature sensing device associated with the main waterway for detecting temperature of water within the main waterway, and a water pump disposed in the main waterway for being started or stopped in accordance with the water temperature detected by the temperature sensing device. In this way, the water circulation module is able to determine to start or stop the preheating circulation by itself and control the preheating circulation of the water consuming system where it locates individually.

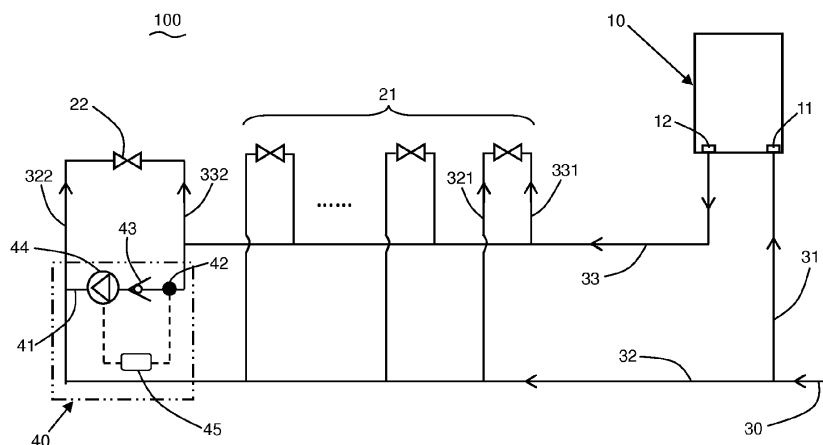


Fig. 1A

Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of hot water system, and more particularly to a water circulation module suitable for domestic hot water system.

BACKGROUND OF THE INVENTION

[0002] When turning on a hot faucet to start a gas water heating appliance, such as a gas water heater, a user often has to wait a long time for hot water output from the hot faucet. This is because, on one hand, there is a large amount of cold water remaining in water pipelines within or outside of the appliance, and this amount of cold water has to be drained out first and then hot water comes out; on the other hand, at the beginning of starting the gas water heater, for consideration of security, a blower will be first activated to exhaust residual gas within the combustion chamber and flue pipes, and the combustion burner will be ignited after the residual gas being all replaced by fresh air, during the period, hot faucet continuously outputs cold water. Obviously, the big volume of drained cold water causes the waste of water resources. In addition, this will lead to a poor user experience, for example, when the user desires to take a shower in winter, the user has to wait a long time to get hot water.

[0003] One of the applicants of present application has ever filed a patent application that has been published with the number CN 105299875 A and discloses a gas-fired water heating appliance having a preheat function. The appliance is provided with a water pump and a water tank for preheating cold water in the pipelines before a user can use it so that hot water can be supplied immediately when the user turns on the hot water faucet, thereby improving the user's experience. However, this preheating means requires a return pipe preset between the hot faucet and the gas heating appliance, if the return pipe has not been reserved on decoration of users' home, such means obviously could not be applied.

[0004] In the state of art, the preheating water circulation can also be realized by connecting a return pipe section in parallel with a water mixing valve performing as a water consuming point, such as shown in a Chinese Utility Model Publication CN 205332549 U, when there is no water consuming demand at the water mixing valve, hot water comes out from the water heating appliance passes through hot water pipelines, the return pipe section, cold water pipelines, and returns to the water heating appliance, thereby preheating cold water within the circulation pipelines. Since this means does not require a long water return pipe between the water consuming point and the water heating appliance, it can be applied to the user's home that has been finished decoration. Nevertheless, there are often more than two water consuming subsystems existing in one user's home, for example, two bathrooms. These multiple subsystems are

supplied hot water from the same water heating appliance, and the multiple subsystems are arranged in parallel, it is therefore clear that this preheating means could not be used to control each of the multiple subsystems individually.

SUMMARY OF THE INVENTION

[0005] It is an object of present invention to provide a water circulation module which can be installed in a hot water system to establish a preheating water circulation therein and achieve an individual control to this preheating water circulation.

[0006] It is another object of present invention to provide a hot water system employing the above water circulation module.

[0007] According to one aspect of the present invention there is provided a water circulation module adapted to be installed in a hot water system including a water heating appliance having an water inlet and a water outlet, a cold water pipeline in communication with the water inlet, and a hot water pipeline in communication with the water outlet. The water circulation module is disposed outside the water heating appliance and connected between the hot water pipeline and the cold water pipeline, so as to selectively establish a water circulation path between itself and the water heating appliance and thereby heating cold water in the water circulation path. The water circulation module includes a main waterway, a temperature sensing device associated with the main waterway for detecting temperature of water within the main waterway, and a water pump disposed in the main waterway for being started or stopped in accordance with the water temperature detected by the temperature sensing device.

[0008] In one embodiment, the water circulation module further includes a housing, an auxiliary water heating device, a first pipeline and a second pipeline. The housing has an inlet port, a first outlet port, and a second outlet port. The auxiliary water heating device is disposed in the housing and having a water intake and a water exit. The first pipeline is disposed between the inlet port and the water intake of the auxiliary water heating device, and the second pipeline is disposed between the second outlet port and the water exit of the auxiliary water heating device. The main waterway is disposed between the inlet port and the first outlet port.

[0009] In one embodiment, the water circulation module further includes a check valve provided in the main waterway.

[0010] Preferably, the check valve has a specific cracking pressure.

[0011] Preferably, the specific cracking pressure equals to or is larger than 300 mbar.

[0012] Preferably, the water circulation module further includes a controller electrically connected with the temperature sensing device and the water pump for controlling the water pump to be started or stopped in accord-

ance with the water temperature detected by the temperature sensing device.

[0013] Preferably, when the water temperature detected by the temperature sensing device is less than a first temperature threshold, the controller starts the water pump; when the water temperature equals to or is larger than a second temperature threshold that is higher than the first temperature threshold, the controller stops the water pump.

[0014] In an alternative embodiment, the water circulation module further includes an electromagnetic valve provided in the main waterway.

[0015] Preferably, the auxiliary water heating device is an electric water heating device.

[0016] Preferably, the first pipeline includes a portion of the main waterway.

[0017] According to another aspect of the present invention there is provided a hot water system including a water heating appliance having a water inlet and a water outlet, a cold water pipeline and a hot water pipeline. The cold water pipeline communicates with the water inlet and the hot water pipeline communicates with the water outlet. At least one first water mixing valve communicates with the cold water pipeline and the hot water pipeline. A second water mixing valve is disposed farther from the water heating appliance than the at least one first water mixing valve along the hot water pipeline and/or the cold water pipeline. A water circulation module as aforementioned is provided downstream of the at least one first water mixing valve and in communication with the hot water pipeline, the cold water pipeline, and the second water mixing valve.

[0018] Compared with the state of art, the present invention has the advantages that: the water circulation module is provided with a temperature sensing device and a water pump, and the water pump can be started or stopped in accordance with the water temperature detected by the temperature sensing device, in other words, the water circulation module is able to determine to start or stop the preheating circulation by itself and control the preheating circulation of the water consuming system where it locates individually.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Figs. 1A and 1B are schematic diagrams of the working principle of a hot water system in accordance with a first embodiment of present invention; wherein Fig. 1A shows that the hot water system is in a normal water consuming mode and a water circulation module does not work, Fig. 1B shows that the hot water system is in a preheating mode and the water circulation module is working;

Figs. 2A to 2C are schematic diagrams of the working principle of a hot water system in accordance with a second embodiment of present invention; wherein Fig. 2A shows that the hot water system is in a normal water consuming mode and a water circulation module does not work, Fig. 2B shows that the hot water system is in a preheating mode and the water circulation module is working, and Fig. 2C shows the hot water system with an electrical water heating device of the water circulation module working and a water pump stopping working;

Fig. 3 is a schematic diagram of the working principle of a hot water system in accordance with a third embodiment of present invention, which is similar to Fig. 2, wherein the electric water heating device is disposed outside the water circulation module;

Fig. 4 is a schematic diagram showing the working principle of a hot water system that consists of two water consuming subsystems connected in parallel each including the water circulation module as shown in Fig. 2;

Fig. 5 is a schematic diagram of the working principle of a hot water system in accordance with a fourth embodiment of present invention;

Fig. 6 is a schematic diagram of the working principle of a hot water system in accordance with a fifth embodiment of present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Reference will now be made to the drawing figures to describe the preferred embodiments of the present invention in detail. However, the embodiments can not be used to restrict the present invention. Changes such as structure, method and function obviously made to those of ordinary skill in the art are also protected by the present invention.

[0021] A hot water system of present invention is suitable for domestic applications and can be used for providing domestic hot water and/or space heating. The hot water system includes a water heating appliance which can be fired with combustible gas, or powered by an electric heating rod, or a solar water heater, or a heat pump, etc.. The water heating appliances fired with combustible can be gas water heaters for supplying hot water for domestic sanitary usage or gas boilers for heating living space, and a gas water heater will be exemplified hereinafter.

[0022] Refer to Figs. 1A and 1B, a hot water system in accordance with a first embodiment of present invention is denoted with reference numeral 100, and a gas water heater of the hot water system is denoted with reference numeral 10. The gas water heater 10 typically includes

a casing, and a gas burner as well as a heat exchanger both housed within the casing. When the gas water heater 10 performs a normal heating operation, the burner ignites a mixture of gas and air, and the mixture is combusted in a combustion chamber defined between the burner and the heat exchanger. The high-temperature flue gas generated by the combustion passes through the heat exchanger driven by a fan, and the heat is absorbed by the water passing through pipes coiled outside the heat exchanger. A water inlet 11 and a water outlet 12 are provided at the bottom of the gas water heater 10. The cold water coming from water mains 30 enters the gas water heater 10 via a water pipe 31 and the water inlet 11 for being heated, and then hot water is discharged through the water outlet 12. Since the construction and working principle of the gas water heater are well known to those skilled in the art, a detailed description is omitted for purpose of brevity and simplicity.

[0023] The hot water system 100 includes a cold water pipeline 32 communicating with the water mains 30 and communicating with the water inlet 11 of the gas water heater 10 via the water pipe 31, and a hot water pipeline 33 communicating with the water outlet 12 of the gas water heater. The hot water pipeline mainly refers to the pipes for being flowed through by hot water when the gas water heater 10 is in operation, but when the water heater 10 is not working, the water retained in the hot water pipeline will be gradually cooled to a room temperature which at this time equals to the temperature of water existed in the cold water pipelines 32. The hot water system 100 further includes a number of water consuming points where a number of water mixing valves is positioned respectively, and two opposite ends of each water mixing valve respectively communicate with the hot water pipeline 33 and the cold water pipeline 32. As shown in Fig. 1A, when the gas water heater 10 works at a normal heating mode, the hot water exiting from the water outlet 12 flows to the water mixing valve via the hot water pipelines 33 and the water pipes 331, 332, and in the meantime, the cold water from the water mains 30 flows through the cold water pipeline 32 and water pipes 321, 322 to the water mixing valve, so as to be mixed with the hot water to be output at an appropriate temperature. These water consuming points are usually arranged at the same place, such as the same bathroom or the same kitchen room. Take a bathroom as example, water consuming points can be bath shower faucet, basin faucet, or flush toilet. In this embodiment, the hot water system 100 includes a water circulation module 40 connected between the hot water pipeline 33 and the cold water pipeline 32. Preferably, the water circulation module 40 is disposed at the water consuming point farthest from the gas water heater 10. Since the water circulation module 40 can connect the hot water pipeline 33 and the cold water pipeline 32, when the water consuming points are all not used, the gas water heater 10 can work to preheat the cold water both in the cold and the hot water pipelines 32, 33, in this way, the water circulation module 40 lo-

cated at the farthest point away from the gas water heater 10 helps to keep all of water remaining in the cold and the hot water pipelines 32, 33 uniformly heated, so that any of the water consuming points can immediately access hot water as soon as the faucets thereof are turned on. Thus, the water mixing valves of the water consuming points can be divided into a first water mixing valve 21 located closer to the gas water heater 10 along the cold and/or the hot water pipelines 32 and 33, and a second water mixing valve 22 located further away from the gas water heater 10. In the present embodiment, the second water mixing valve 22 is the farthest one away from the gas water heater 10, which can be a basin faucet. In this case, the water circulation module 40 can be installed below the washbasin, for example, it can be installed in a washbasin cabinet, which would not be awkward for the users who have completed the home decoration before. Of course, in other embodiments, if the farthest point does not require the use of hot water, such as a flush toilet, or a basin faucet equipped with a small-sized, instantaneous water heater, in such case, the second water mixing valve 22 equipped with the water circulation module 40 is not necessarily at the point farthest from the gas water heater 10 in the hot water system. Of course, there is usually at least one first water mixing valve 21 upstream of the second water mixing valve 22.

[0024] In the present embodiment, the water circulation module 40 is disposed downstream of the first water mixing valve 21 and in parallel with the second water mixing valve 22. The water circulation module 40 includes a main waterway 41, a temperature sensing device 42 in associated with the main waterway 41 to detect the temperature of water in the main waterway, and a water pump 44 disposed in the main waterway 41. The water circulation module 40 may have a housing, and the main waterway 41 can be defined by a water pipe provided in the housing, and the water pipe may be connected to the cold and the hot water pipelines 32, 33 through pipe joints. The temperature detecting device 42 may be a thermistor, such as a negative temperature coefficient (NTC) thermistor, which may be disposed in the main waterway 41 to reflect the temperature value by the resistance value. The water pump 44 may be a conventional circulation pump. A check valve 43 may also be provided in the main waterway 41 to restrict the water flow in a specific direction. In this embodiment, the water circulation module 40 further includes a controller 45 disposed in the housing of the water circulation module 40. The controller 45 may be a logic control circuit in which a number of electronic components are connected in a certain wiring manner, or may incorporate a microcontroller (MCU) which stores program instructions, or may be an integrated chip with a proprietary use, such as ASIC (Application Specific Integrated Circuit), or FPGA (Field Programmable Gate Array), etc.. The controller 45 can be electrically connected to the temperature sensing device 42 and the water pump 44 through electrical wires.

[0025] As shown in Fig. 1B, when the hot water system works at a preheating mode, in the water circulation module 40, the controller 45 obtains the temperature of water within the main waterway 41 through the temperature sensing device 42. As the detected temperature is less than a first temperature threshold, which indicates that the water temperature in the cold and the hot water pipelines 32 and 33 is too low, then the controller activates the water pump 44 to start the preheating. The first temperature threshold can be set to an acceptable comfortable temperature for users, such as 30°C. Then water in the hot water pipeline 33 is pumped into the water circulation module 40 and flows out of the module through the main waterway 41 and further into the cold water pipeline 32, after that, the water enters the gas water heater 10 via the water pipe 31 and the water inlet 11 to be heated, and then passes through the water outlet 12 and flows again into the hot water pipelines 33, thus the cycle repeats. At the same time, the controller 45 continuously obtains the temperature of water in the main waterway 41 through the temperature sensing device 42. When the detected water temperature is greater than or equals to a second temperature threshold that is larger than the first temperature threshold, the controller 45 stops the water pump 44, then the preheating water circulation stops accordingly. Since the water in the cold and the hot water pipelines 32 and 33 has a relatively higher temperature in the preheating mode, the second temperature threshold is not suitable to set too high as it may burn a user if the user turns on a faucet at this time, therefore, in the present embodiment, the second temperature threshold is set at 35°C.

[0026] Figs. 2A and 2C show a hot water system 200 in accordance with a second embodiment of present invention. The main difference from the hot water system 100 of the first embodiment aforementioned is that, a water circulation module 50 includes an electric water heating device 56 functioning as an auxiliary water heating device. The electric water heating device 56 can be a small-sized instant electric water heater or a small storage type electric water heater including a water tank. In the present embodiment, the second water mixing valve 22 is disposed at a water consuming point farthest from the gas water heater 10 along the cold water pipeline 32, and the electric water heating device 56 is used for supplying hot water to this water consuming point, therefore, the hot water exiting from the gas water heater 10 is not needed at this point. The electric water heating device 56 has a cold water intake 561 and a hot water exit 562.

[0027] As shown in Fig. 2A, the water circulation module 50 is disposed downstream of the first water mixing valve 21 and connected between the cold and the hot water pipelines 32 and 33. One end of the second water mixing valve 22 communicates with the cold water pipeline 32 through the water pipe 322 and the other end communicates with the hot water exit 562 of the electric water heating device through the water pipe 342. In this embodiment, the water circulation module 50 also in-

cludes a main waterway 51, a temperature sensing device 52 disposed in the main waterway 51, a check valve 53, a water pump 54, and a controller 55 electrically connected to the temperature sensing device 52 and the water pump 54. In addition, the water circulation module 50 further includes a first sub-waterway connected with the cold water intake 561 of the electric water heating device, a second sub-waterway 341 connected with the cold water pipelines 32, and a three-way valve 58 provided among the main waterway 51 and the first and the second sub-waterways. The controller 55 communicates with the three-way valve 58, for example, the controller 55 controls the three-way valve 58 by using an electric wired connection to selectively connect any two of the main waterway, the first and the second sub-waterways. A flow sensor 57 is provided in the first sub-waterway. The controller 55 is electrically connected to the flow sensor 57, so as to stop the water pump 54 when the flow sensor 57 detects there is a water flow in the first sub-waterway. Preferably, the hot water system 200 further includes a contact switch 59 electrically connected to the controller 55. The contact switch 59 may be mounted on a wall for the user to manually trigger the preheating mode. Of course, the contact switch can also be integrated into a remote control of the gas water heater to be triggered to start the preheating mode through a wireless communication. In addition, the activation of the preheating mode can also be achieved by setting a timer disposed in the water circulation module 50 or by a specific application on the user's mobile phone.

[0028] As shown in FIG. 2B, when the hot water system 200 is operating in the preheating mode and the water pump 54 is in operation, since none of the water mixing valves at the water consuming points is open at this time, the water in the hot water pipeline 33 enters the water circulation module 50, and flows out of the module through the main waterway 51 and the second sub-waterway 341 successively, then flows into the gas water heater 10 through the cold water pipeline 32 and the water pipe 31 for being heated, and the hot water flows out again into the hot water pipeline 33. The cycle is repeated until the temperature of water in the circulation lines reaches the second temperature threshold. Obviously, the water preheated in the circulation lines in this embodiment is mainly used for the water consuming point where the first water mixing valve 21 locates.

[0029] As shown in FIG. 2C, when there is a hot water demand at the water consuming point where the second water mixing valve 22 locates, the cold water in the cold water pipeline 32 is divided into two paths, the water in one path is directly supplied to the second water mixing valve 22, and the water in the other path passes through the second sub-waterway 341 and the first sub-waterway then enters the electric water heating device 56 for being heated, and then the hot water is supplied to the second water mixing valve 22 through the water pipe 342 so as to mix with the cold water from another path to reach a proper temperature for being used. At the same time,

when the flow sensor 57 disposed in the first sub-waterway detects a water flow therein, the controller 55 obtains a signal from the flow sensor 57 indicating the water flow, and then the controller 55 controls the water pump 54 to stop operation.

[0030] Fig.3 shows a hot water system 300 in accordance with a third embodiment of present invention, which differs from the hot water system 200 as shown in FIG. 2 only in that, the electric water heating 16 is located outside the water circulation module 60, that is, the water circulation module 60 does not include the electric water heating device 16. This case is mainly applicable to the situation that, a small-sized instant electric water heater has already existed near the basin faucet in the user's home, and apparently the water circulation module as shown in Fig. 2 could not be applied to this situation.

[0031] As shown in Fig. 4, when a hot water system consists of multiple water consuming subsystems connected in parallel in a user's home, and the multiple subsystems are supplied hot water by the same water heating appliance 10, the preheating water circulation of each subsystem can be controlled individually by providing a water circulation module in each of the subsystem. In the hot water system as shown in Fig. 4, the water circulation module of the second embodiment is adopted, of course, the water circulation modules disclosed in other embodiments may also be applied to this hot water system.

[0032] Fig. 5 shows a hot water system 400 in accordance with a forth embodiment of present invention. The hot water system 400 also includes a water heating appliance 10, a cold water pipeline 32 in communication with the water inlet of the water heating appliance 10, a hot water pipeline 33 in communication with the water outlet of the water heating appliance 10, a number of first water mixing valves 21, and the second water mixing valve 22 is located downstream of the first water mixing valves. The second water mixing valve 22 is farther from the water heating appliance 10 than the first water mixing valves 21 along the hot water pipeline and/or the cold water pipeline. The second water mixing valve 22 may be located at the end of the hot/cold water pipeline, however, in the present embodiment, the second water mixing valve 22 is not the farthest one away from the water heating appliance 10, and there is another water consuming point downstream thereof.

[0033] The hot water system 400 also includes a water circulation module 70. The water circulation module 70 includes a housing 79 having an inlet port 701, a first outlet port 702, and a second outlet port 703. The inlet port 701 and the first and the second outlet ports 702 and 703 may take the form of pipe joints. An auxiliary water heating device 76 is disposed in the housing 70, which may be an electric water heating device, such as a small-sized instant electric water heater or a small storage type electric water heater including a water tank. In the present embodiment, the auxiliary water heating device is a storage type electric water heater with a 4-liters water tank. Within the housing 70, water pipes connected between

the inlet port 701 and the first outlet port 702 forms a main waterway 71. One end of the main waterway 71 communicates with the hot water pipeline 33 through the inlet port 701, and the other end of the main waterway 71 communicates with the cold water pipeline 32 through the first outlet port 702. In addition, water pipes connected between the inlet port 701 and a water intake of the auxiliary water heating device 76 forms a first pipeline 77, and water pipes connected between a water exit of the auxiliary water heating appliance 76 and the second outlet port 703 forms a second pipeline 78. In the present embodiment, the first pipeline 77 includes a part of the main waterway 71.

[0034] Similar to the aforementioned embodiments, the water circulation module 70 includes a temperature sensing device 72 associated with the main waterway 71 to detect the temperature of water in the main waterway, a water pump 73 disposed in the main waterway 71, and a controller 75 electrically connected to the temperature sensing device 72 and the water pump 73. The controller 75 may control start and stop of the water pump 73 based on the water temperature detected by the temperature sensing device 72. A check valve 74 is also provided in the main waterway 71 to define the flow direction of the water flow from the inlet port 701 to the first outlet port 702. The check valve 74 has a specific cracking pressure, by this means, only when the water pump 73 is in operation, which results in the water pressure in the main waterway exceeds the specific cracking pressure, the check valve 74 then opens. In the present embodiment, the specific cracking pressure equals or is larger than 300 mbar.

[0035] As shown in Fig. 5, when the hot water system 400 works in the preheating mode, the water pump 73 is operated, the water in the hot water pipeline 33 enters the water circulation module 70 through the inlet port 701, and passes through the main waterway 71 and the first outlet port 702 then enters the cold water pipeline 32, and it further passes through the water pipe 31 to enter the water heating appliance 10 for being heated. The hot water then flows out and again into the hot water pipeline 33. The cycle repeats until the water temperature reaches a predetermined temperature value, after that, the pump stops working. When a cold water demand is needed at the second water mixing valve 22, the cold water flows through the cold water pipeline 32 and the water pipe 322 to the second water mixing valve 22. At this time, the water pump 73 does not work, and since the check valve 74 has a certain cracking pressure, the check valve 74 plays an obstacle role to some extent in the main waterway 71, so that the hot water stored in the hot water pipeline 33 for preheating purpose does not enter the cold water pipeline 32 through the first outlet port 702, or only very small amount of hot water enters the cold water pipeline 32 through the first outlet port 702, however which does not affect the use of cold water at the second water mixing valve 22. When there is a hot water demand at the second water mixing valve 22, the cold

water passes through the cold water pipeline 32 and the water pipe 322 to the second water mixing valve 22; and the hot water stored in the auxiliary water heating device 76 can immediately pass through the second pipeline 78, the second outlet port 703, and the water pipe 342 to the second water mixing valve 22, then mixes with the cold water to be discharged at a proper temperature. When the hot water demand at the second water mixing valve 22 exceeds the capacity of hot water production of the auxiliary water heating appliance 76, the water heating appliance 10 starts work to supplement the shortage of the hot water, thus, the hot water output from the water heating appliance 10 is added into the auxiliary water heating device 76 through the hot water pipeline 33, the inlet port 701 and the first pipeline 77 successively, thereby ensuring that the auxiliary water heating device 76 can output sufficient hot water.

[0036] Fig. 6 shows a hot water system 500 in accordance with a fifth embodiment of present invention. A water circulation module 80 in this embodiment is similar to the water circulation module 70 in the fourth embodiment. The water circulation module 80 also includes a housing 89 having an inlet port 801, a first outlet port 802 and a second outlet port 803, an auxiliary water heating device 86, a main waterway 81 connected between the inlet port 801 and the first outlet port 802, a first pipeline 87 connected between the inlet port 801 and a water intake of the auxiliary water heating device 86, a second pipeline 88 connected between a water exit of the auxiliary water heating device 86 and the second outlet port 803. The main waterway 81 is provided with a temperature sensing device 82 and a water pump 83. Different from the fourth embodiment, a solenoid valve 84 is disposed in the main waterway 81. A controller 85 is electrically connected to the temperature sensing device 82, the water pump 83, and the electromagnetic valve 84. When the temperature of water in the main waterway 81 is too low and needs to be preheated, the controller activates the electromagnetic valve 84 and drives the water pump 83 to work, so that the cold water is heated circularly; when the temperature sensing device 82 detects that the water temperature reaches the predetermined value, the controller 85 stops the operation of the water pump 83 and activates the solenoid valve 84 to disconnect the main waterway 81 so as to prevent the hot water in the hot water pipeline 33 from entering the cold water pipeline when there is cold water demand at the second water mixing valve 22.

[0037] It is to be understood, however, that even though numerous, characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosed is illustrative only, and changes may be made in detail, especially in matters of number, shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broadest general meaning of the terms in which the appended claims are expressed.

Claims

1. A water circulation module (40, 50, 60, 70, 80) adapted to be installed in a hot water system (100, 200, 300, 400, 500) comprising a water heating appliance (10) having an water inlet (11) and a water outlet (12), a cold water pipeline (32) in communication with the water inlet (11), and a hot water pipeline (33) in communication with the water outlet (12); said water circulation module being disposed outside the water heating appliance and connected between the hot water pipeline and the cold water pipeline, so as to selectively establish a water circulation path between itself and the water heating appliance and thereby heating cold water in the water circulation path, **characterized in that**, said water circulation module comprises a main waterway (41, 51, 71, 81), a temperature sensing device (42, 52, 72, 82) associated with the main waterway for detecting temperature of water within the main waterway, and a water pump (44, 54, 73, 83) disposed in the main waterway for being started or stopped in accordance with the water temperature detected by the temperature sensing device.
2. A water circulation module (70, 80) according to claim 1, **characterized in that** said water circulation module further comprises:
 - a housing (79, 89) having an inlet port (701, 801), a first outlet port (702, 802), and a second outlet port (703, 803);
 - an auxiliary water heating device (76, 86) disposed in the housing and having a water intake and a water exit;
 - a first pipeline (77, 87) disposed between the inlet port (701, 801) and the water intake of the auxiliary water heating device, and a second pipeline (78, 88) disposed between the second outlet port (703, 803) and the water exit of the auxiliary water heating device; wherein said main waterway is disposed between the inlet port (701, 801) and the first outlet port (702, 802).
3. A water circulation module (40, 50, 60, 70) according to claim 1 or 2, **characterized in that** the water circulation module further comprises a check valve (43, 53, 74) provided in the main waterway (41, 51, 71).
4. A water circulation module (70) according to claim 3, **characterized in that** said check valve (74) has a specific cracking pressure.
5. A water circulation module (70) according to claim 4, **characterized in that** said specific cracking pressure equals to or is larger than 300 mbar.

6. A water circulation module (40, 50, 60, 70, 80) according to claim 1, **characterized in that** said water circulation module further comprises a controller (45, 55, 75, 85) electrically connected with the temperature sensing device and the water pump for controlling the water pump to be started or stopped in accordance with the water temperature detected by the temperature sensing device. 5

7. A water circulation module (40, 50, 60, 70, 80) according to claim 6, **characterized in that**, when the water temperature detected by the temperature sensing device is less than a first temperature threshold, the controller starts the water pump; when said water temperature equals to or is larger than a second temperature threshold that is higher than the first temperature threshold, the controller stops the water pump. 10
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8. A water circulation module (80) according to claim 1 or 6, **characterized in that** the water circulation module further comprises an electromagnetic valve (84) provided in the main waterway (81). 20

9. A water circulation module (70, 80) according to claim 2, **characterized in that** said auxiliary water heating device is an electric water heating device. 25

10. A water circulation module (70, 80) according to claim 2, **characterized in that** said first pipeline comprises a portion of the main waterway. 30

11. A hot water system, **characterized in that**, said system comprises: 35
 - a water heating appliance (10) have a water inlet (11) and a water outlet (12);
 - a cold water pipeline (32) and a hot water pipeline (33), said cold water pipeline (32) communicates with the water inlet (11) and said hot water pipeline (33) communicates with the water outlet (12); 40
 - at least one first water mixing valve (21) communicating with the cold water pipeline and the hot water pipeline; 45
 - a second water mixing valve (22) disposed farther from the water heating appliance than said at least one first water mixing valve along the hot water pipeline and/or the cold water pipeline;
 - a water circulation module according to any of claims 1 to 10 provided downstream of said at least one first water mixing valve and in communication with the hot water pipeline, the cold water pipeline, and the second water mixing valve. 50
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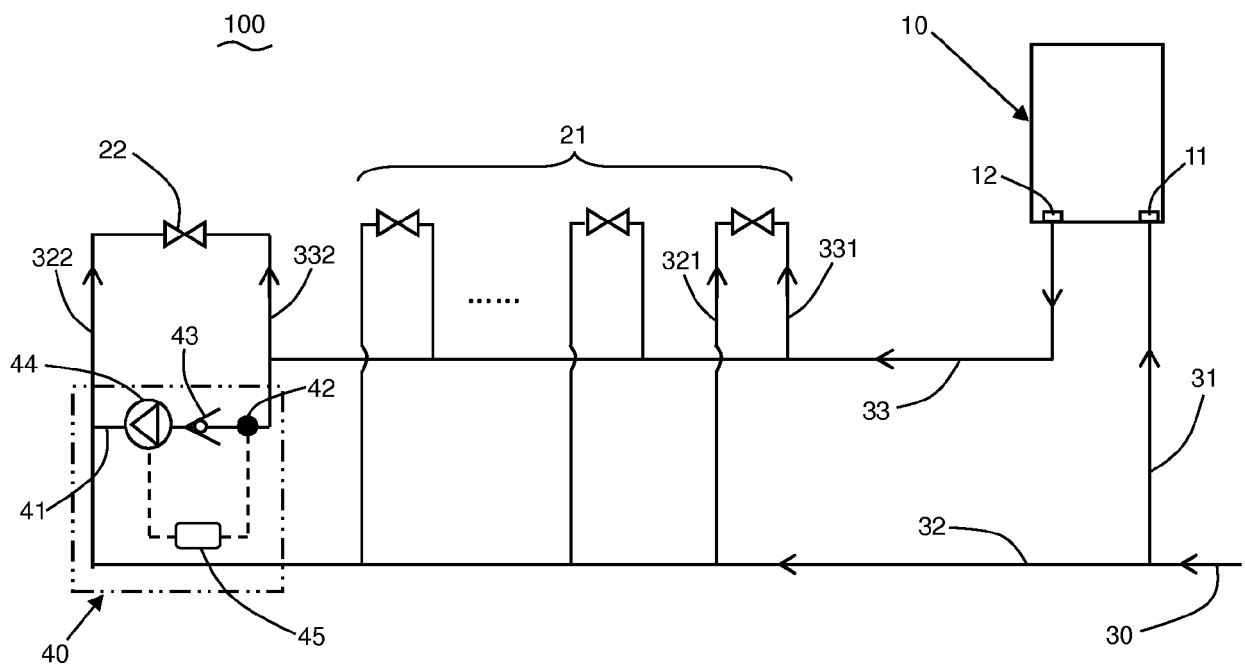


Fig. 1A

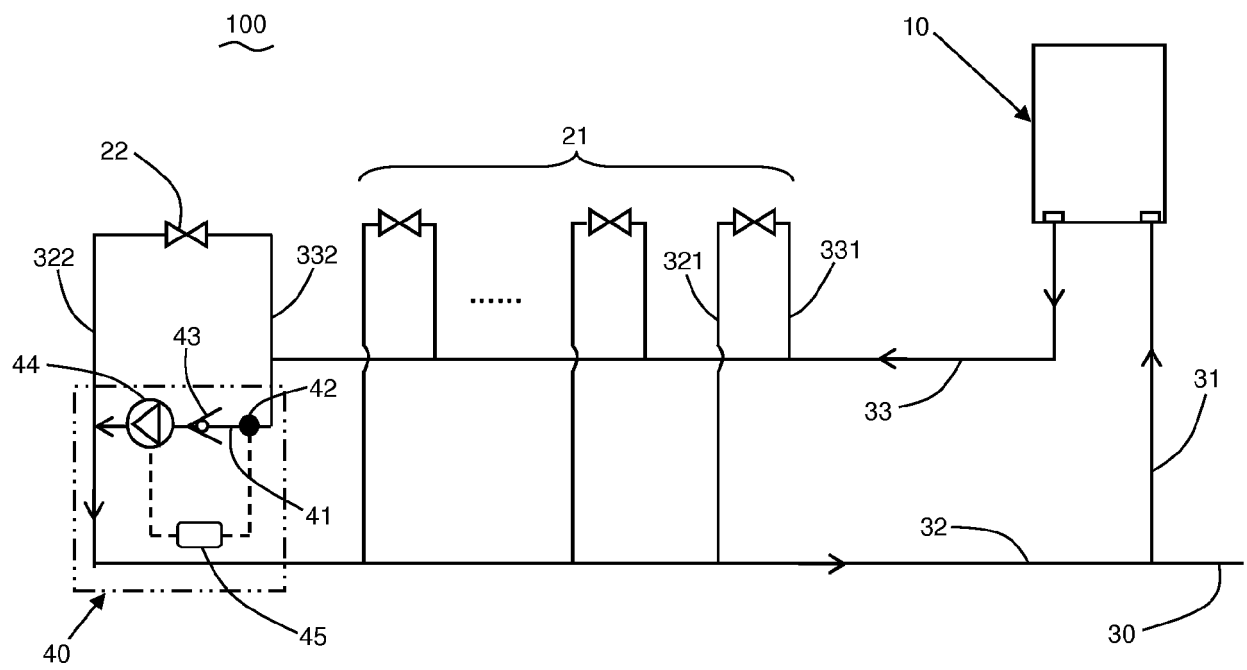


Fig. 1B

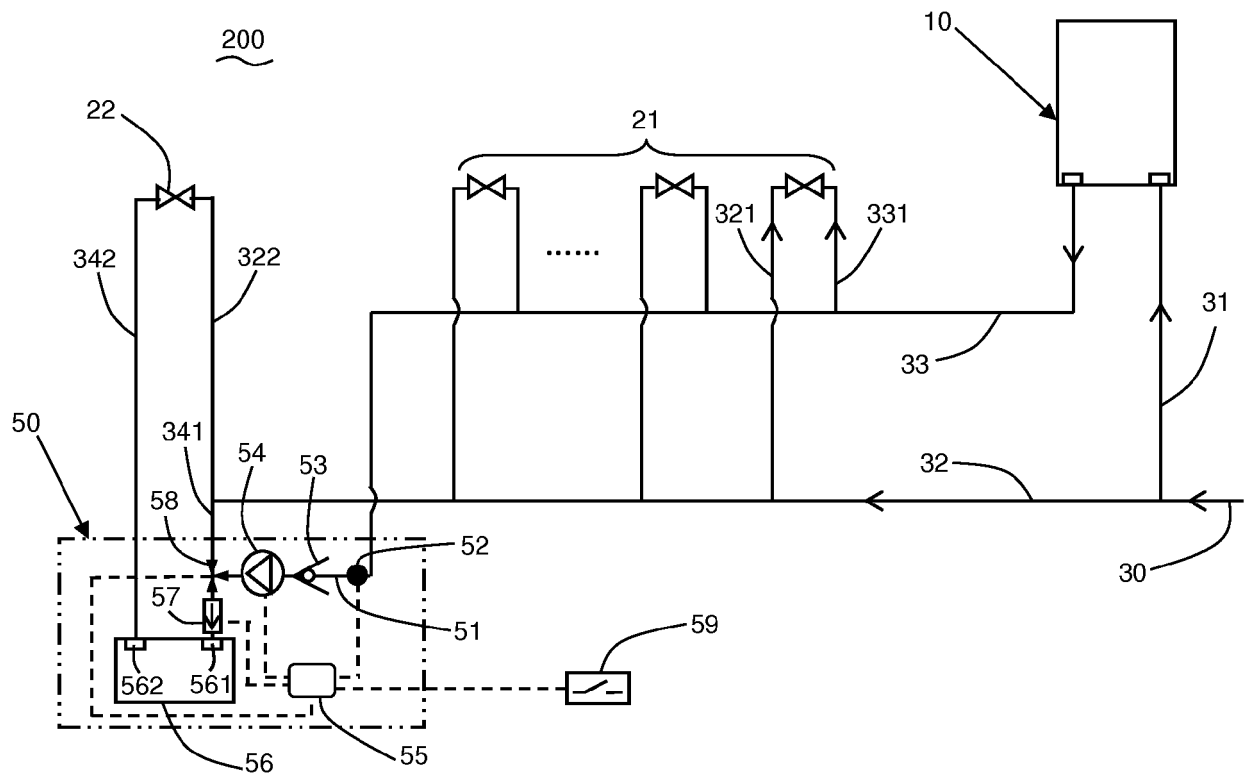


Fig. 2A

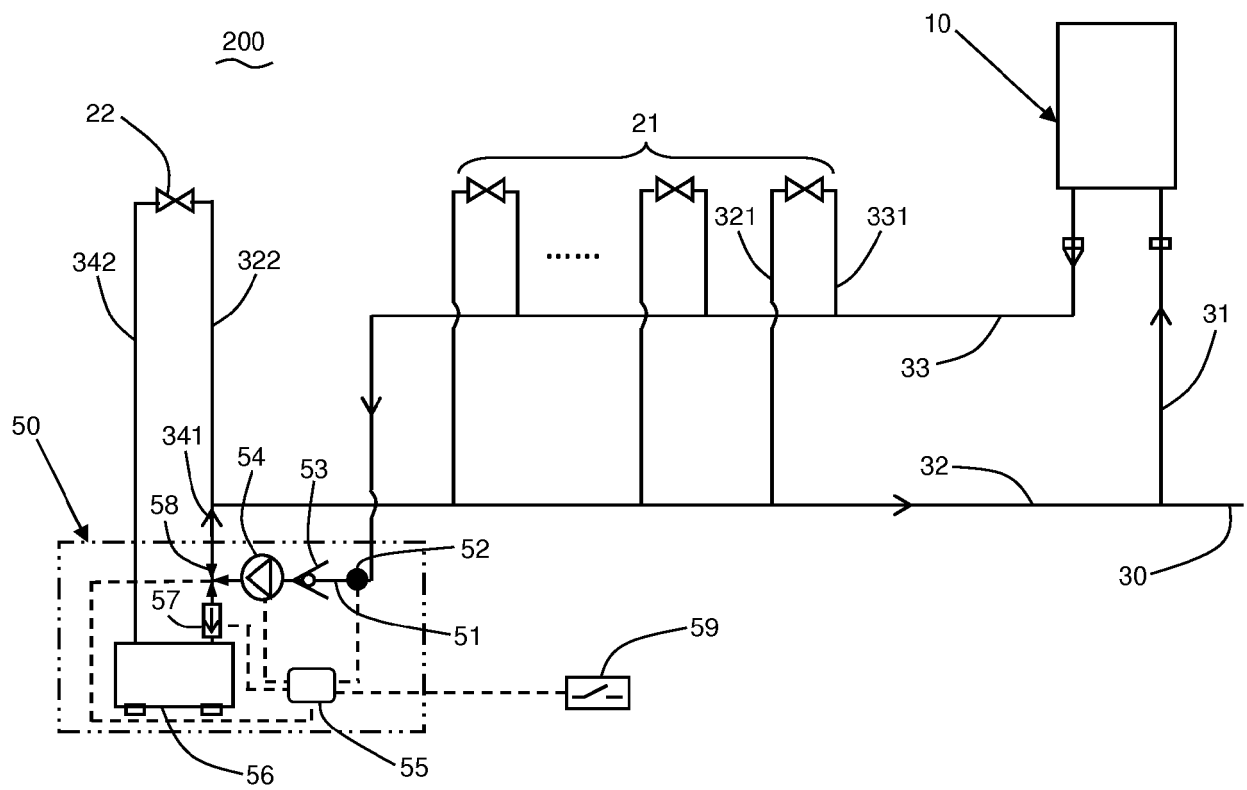


Fig. 2B

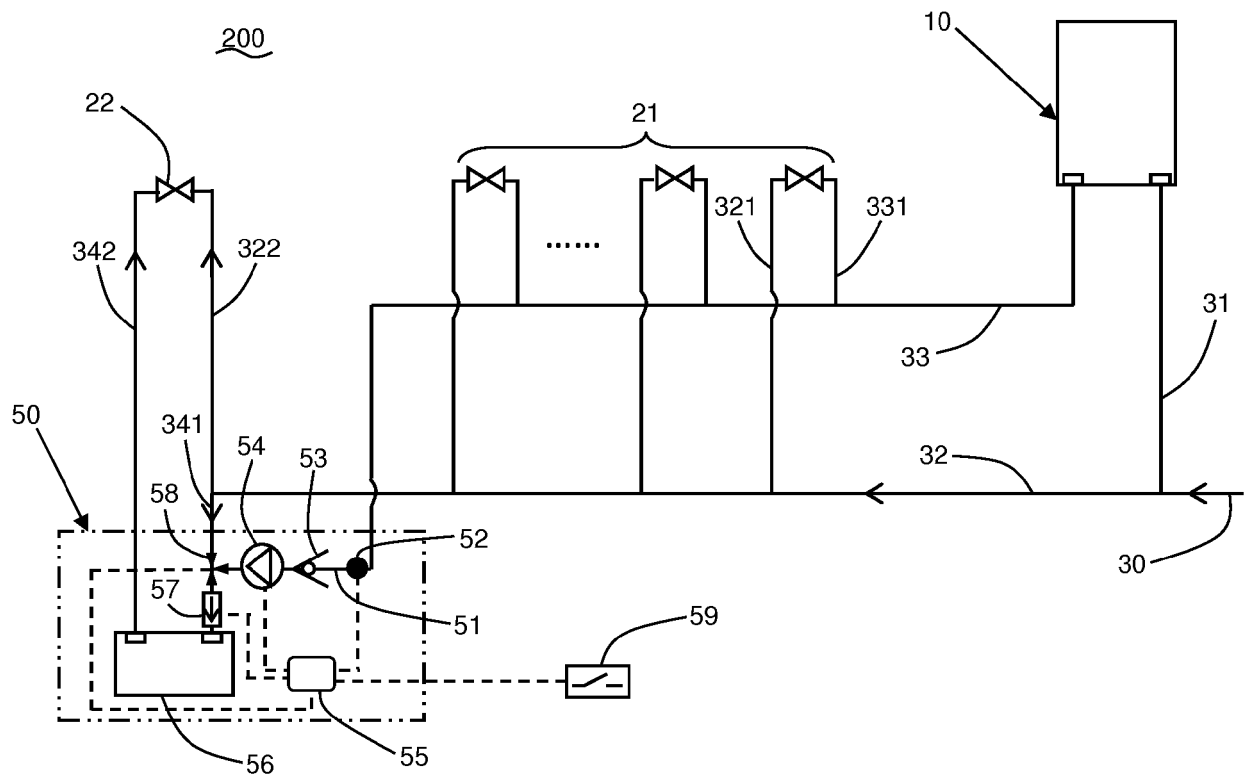


Fig. 2C

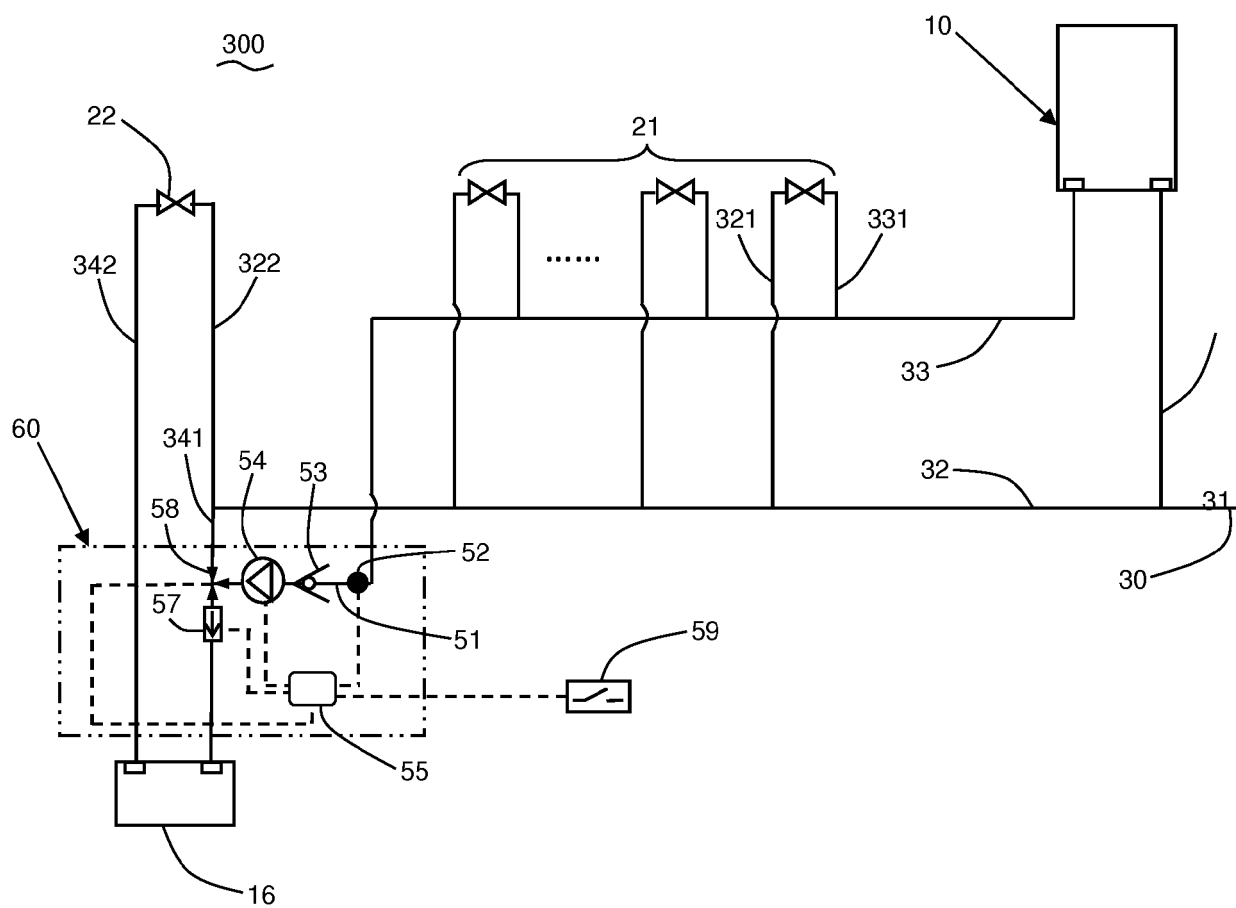


Fig. 3

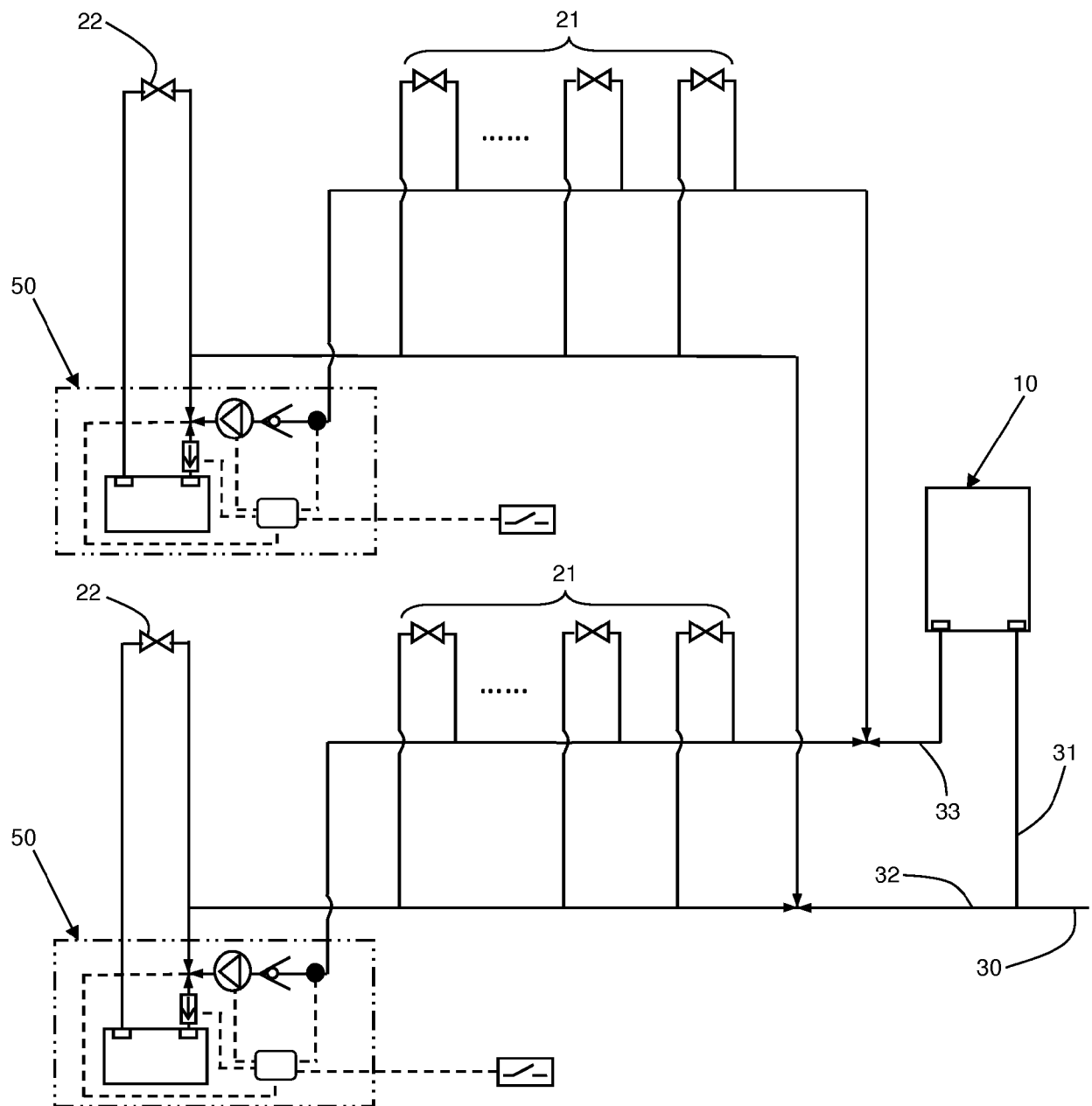


Fig. 4

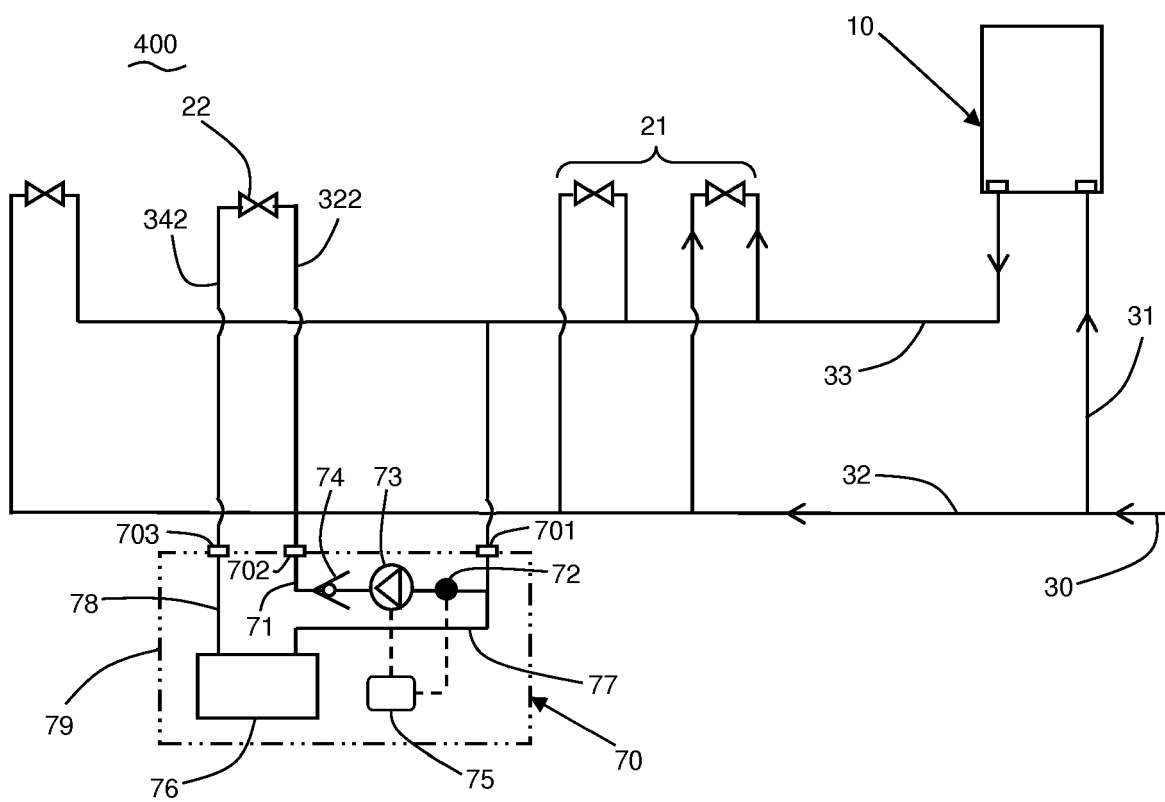


Fig. 5

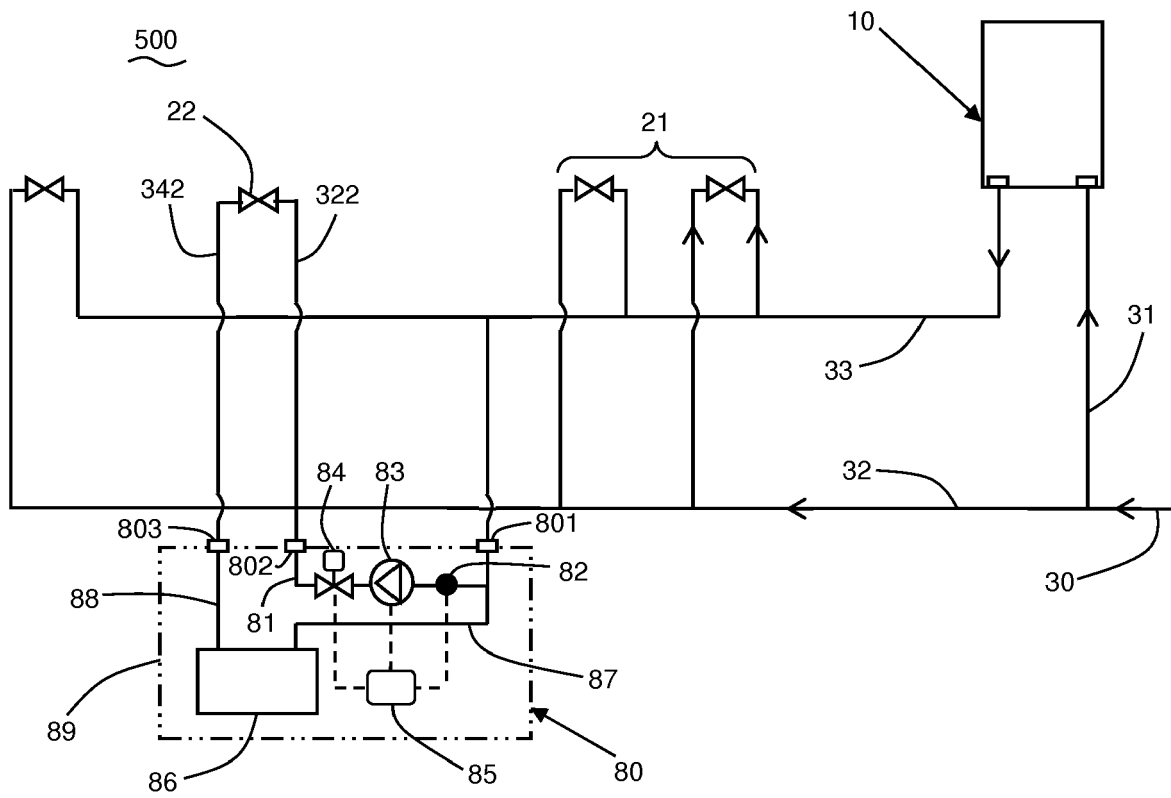


Fig. 6



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