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PRESSURE FILL DEVICE

(57) A pressure fill device (1) comprising an inlet pipe (2), arranged to be connected, in use, to a fluid supply (3), a system outlet pipe (4) and a flow control arrangement (6), arranged to selectively enable supply of fluid from the fluid supply (3) to the system outlet pipe (4). The device (1) further comprising at least one of an inlet fluid flow sensor (8), arranged to detect flow through the inlet pipe (2) and an outlet fluid flow sensor (10), arranged to detect flow through the system outlet pipe (4).

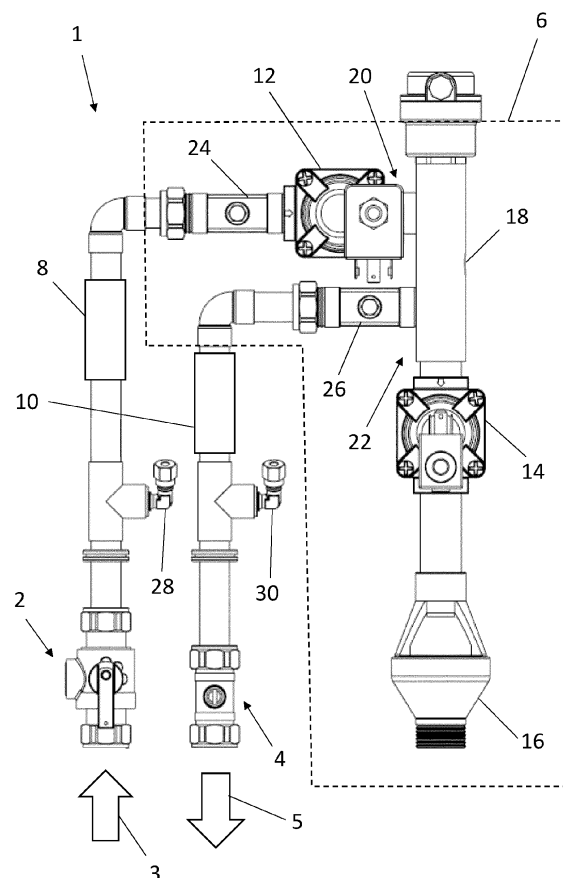


Figure 1

Description**BACKGROUND OF THE INVENTION**

[0001] This invention relates to a pressure fill device.

[0002] It is known to provide closed-loop fluid circulation systems in both domestic and non-domestic properties, for example in order to provide heating or cooling to a property or to a heating or cooling system. It is furthermore known that such systems suffer losses over time, for example due to evaporation or even due to a leak, which cause the pressure in such systems to drop, and eventually cause the pressure in the system to need to be topped up.

[0003] It is known to provide pressure fill devices to supply additional fluid into closed-loop fluid circulation systems in order to increase the pressure and compensate for losses that have occurred over time. Some such devices are arranged to "top up" pressure in a closed-loop fluid circulation system without the need for a pump, by selectively connecting the closed-loop fluid circulation system to a pressurised fluid supply, such as a mains water supply. The pressure from the connected system allows the fluid in the closed-loop fluid circulation system to be "topped up" without the use of a pump.

[0004] The present invention seeks to provide an improved pressure fill device.

SUMMARY OF THE INVENTION

[0005] From a first aspect, the invention provides a pressure fill device, comprising:

an inlet pipe, arranged to be connected, in use, to a fluid supply;
 a system outlet pipe;
 a flow control arrangement, arranged to selectively enable supply of fluid from the fluid supply to the system outlet pipe;
 the device further comprising at least one of:

an inlet fluid flow sensor, arranged to detect flow through the inlet pipe; and
 an outlet fluid flow sensor, arranged to detect flow through the system outlet pipe.

[0006] From a second aspect, the invention provides a method of operating a pressure fill device, the method comprising at least one of:

detecting flow of fluid through an inlet pipe using an inlet fluid flow sensor, the inlet pipe arranged to be connected, in use, to a fluid supply; and
 detecting flow of fluid through a system outlet pipe using an outlet fluid flow sensor, the system outlet pipe arranged to be connected, in use, to a closed-loop fluid circulation system.

[0007] The pressure fill device may further comprise a flow control arrangement, and the method may further comprise:

during a fill operation, enabling supply of fluid from the fluid supply into the closed-loop fluid circulation system using the flow control arrangement; and/or
 not during a fill operation, disabling supply of fluid from the fluid supply into the closed-loop fluid circulation system using the flow control arrangement.

[0008] Thus it will be seen that, in accordance with the invention, by providing a fluid flow sensor on the inlet pipe and/or the outlet pipe, useful information can be obtained about the operation of the pressure fill device.

[0009] For example, the provision of an inlet fluid flow sensor, arranged to detect flow through the inlet pipe, can detect a malfunction during a time when the device is not performing a fill sequence - if flow is detected through the inlet pipe at a time when the device is not performing a fill sequence then there must have been a malfunction of the device since no flow is expected during this state of operation.

[0010] In some embodiments, the method comprises initiating a fault action responsive to detecting flow of fluid through the inlet pipe during a time when the pressure fill device is not carrying out a fill operation. The fault action may comprise outputting an alert signal. The alert signal may be an audible or visual signal. The audible or visual signal may be simple, e.g. a siren sound or flashing light, or it may have informational content, e.g. a spoken or written message containing information about the fault. Alternatively, or in addition, the alert signal may comprise a wireless signal transmitted to an external device, such as a user's mobile device.

[0011] In some embodiments, the flow control arrangement further comprises an inlet pipe valve moveable between an open position in which fluid is able to flow through the inlet pipe valve, and a closed position, in which fluid is prevented from flowing through the inlet pipe valve. The inlet pipe valve may be arranged within the inlet pipe, on the inlet pipe, or adjacent to an end of the inlet pipe.

[0012] In some embodiments, the inlet pipe valve may be a solenoid valve. Solenoid valves may be biased into either a normally open position or a normally closed position depending on the system design. Certain solenoid valves may comprise a diaphragm and a valve seat. The diaphragm may be moved (directly or indirectly) by the solenoid to close the valve by the diaphragm engaging with the valve seat or to open the valve by the diaphragm disengaging from the valve seat.

[0013] In some embodiments, the inlet pipe valve is biased into a closed position. By this it will be understood that when not actuated or moved by an external force, the inlet pipe valve is by default in the closed position (i.e., the position in which the valve prevents flow). The inlet pipe valve must therefore be controlled or actuated

to move to the open position, enabling flow. Thus the presence of the inlet fluid flow sensor makes it possible to detect when the biasing of the inlet pipe valve has failed, since this will mean that the valve enables flow when it shouldn't (i.e., at a time when the pressure fill device is not carrying out a fill operation), as described above.

[0014] The inlet fluid flow sensor may also allow a fault or malfunction to be detected during a flow operation. In this case, if no flow is detected through the inlet fluid flow sensor during a flow operation then it can be detected that the actuation of the inlet pipe valve to the open position has failed since it has not opened to allow flow through the inlet pipe.

[0015] Thus, in some embodiments, the method comprises initiating a fault action responsive to detecting that fluid is not flowing through the inlet pipe, during a time when the pressure fill device is carrying out a fill operation. The fault action may comprise the pressure fill device ceasing the fill operation. In addition, or alternatively, the fault action may comprise outputting an alert signal. The alert signal may be an audible or visual signal. The audible or visual signal may be simple, e.g. a siren sound or flashing light, or it may have informational content, e.g. a spoken or written message containing information about the fault. Alternatively, or in addition, the alert signal may comprise a wireless signal transmitted to an external device, such as a user's mobile device.

[0016] The provision of an outlet fluid flow sensor, arranged to detect flow through the outlet pipe, allows detection of a fault or malfunction during a time when the device is performing a fill sequence - if flow is not detected through the outlet pipe at a time when the device is performing a fill sequence then there must have been a malfunction of the device since flow is expected through the outlet pipe.

[0017] In some embodiments, the flow control arrangement further comprises a drain (e.g., a drain pipe), arranged to drain fluid out of the pressure fill device (i.e., other than to the system outlet pipe. Thus it will be understood that the drain is arranged to drain fluid out of the pressure fill device, such that said fluid does not pass to (and then out of) the system outlet pipe. The drain may be arranged to drain fluid out of the flow control arrangement, for example out of the manifold.

[0018] In some embodiments, the pressure fill device further comprises a drain flow sensor, arranged to detect flow through the drain. Data from this drain flow sensor may be used to give an indication of a fault with the device.

[0019] The drain flow sensor may be arranged to measure the fluid flowing out of the drain. For example, the drain flow sensor may be arranged to measure the rate of flow and/or the volume of fluid flowing out of the drain. This is advantageous since it can be used to give an indication of how much fluid is wasted by the device.

[0020] This is considered to be novel and inventive in its own right, therefore, according to a third aspect of the

present invention, there is provided a pressure fill device, comprising:

an inlet pipe, arranged to be connected, in use, to a fluid supply;
a system outlet pipe;
a flow control arrangement, arranged to selectively enable supply of fluid from the fluid supply to the system outlet pipe, the flow control arrangement comprising a drain, arranged to drain fluid out of the pressure fill device, such that said fluid does not pass to the system outlet pipe;
the device further comprising a drain flow sensor, arranged to detect flow through the drain.

[0021] This has the advantage that it is possible to monitor for faults using this flow sensor. For example, if a fill operation is in progress, such that no flow out of the drain is expected, and flow is detected, then this may be indicative of a fault with the device (e.g., with a drain valve, as discussed below). Furthermore, if flow is detected outside of a fill operation this may be indicative of a fault condition with the device, and this information may be useful even if the data from the drain flow sensor does not allow determination of the exact cause of the fault.

[0022] The drain flow sensor may be arranged to measure the fluid flowing out of the drain (e.g., the rate of flow and/or the volume of fluid). This is advantageous since the drain flow sensor allows the quantity of fluid wasted by the device (i.e., drained out of the drain) to be monitored.

[0023] It will be appreciated that the inlet flow sensor and/or the outlet flow sensor described above (and all optional features described in relation to these flow sensors) may optionally also be present in a pressure fill device according to the third aspect.

[0024] In accordance with a fourth aspect of the present invention, there is provided a pressure fill device, comprising:

an inlet pipe, arranged to be connected, in use, to a fluid supply;
a system outlet pipe;
a flow control arrangement, arranged to selectively enable supply of fluid from the fluid supply to the system outlet pipe, the flow control arrangement comprising a drain, arranged to drain fluid out of the pressure fill device, such that said fluid does not pass to the system outlet pipe;
the device further comprising at least one of:

an inlet fluid flow sensor, arranged to detect flow through the inlet pipe;
an outlet fluid flow sensor, arranged to detect flow through the system outlet pipe; and
a drain flow sensor, arranged to detect flow through the drain.

[0025] Similarly, according to a fifth aspect, the invention further provides a method of operating a pressure fill device, the method comprising at least one of:

detecting flow of fluid through an inlet pipe using an inlet fluid flow sensor, the inlet pipe arranged to be connected, in use, to a fluid supply;
 detecting flow of fluid through a system outlet pipe using an outlet fluid flow sensor, the system outlet pipe arranged to be connected, in use, to a closed-loop fluid circulation system; and
 detecting flow of fluid through a drain using a drain flow sensor, the drain arranged to drain fluid out of the pressure fill device.

[0026] In some embodiments, the method comprises initiating a fault action responsive to detecting flow of fluid through the drain during a time when the pressure fill device is carrying out a fill operation. The fault action may comprise outputting an alert signal. The alert signal may be an audible or visual signal. The audible or visual signal may be simple, e.g. a siren sound or flashing light, or it may have informational content, e.g. a spoken or written message containing information about the fault. Alternatively, or in addition, the alert signal may comprise a wireless signal transmitted to an external device, such as a user's mobile device.

[0027] In some embodiments, the method comprises initiating a fault action responsive to detecting flow of fluid through the drain during a time when the pressure fill device is not carrying out a fill operation. The fault action may comprise outputting an alert signal. The alert signal may be an audible or visual signal. The audible or visual signal may be simple, e.g. a siren sound or flashing light, or it may have informational content, e.g. a spoken or written message containing information about the fault. Alternatively, or in addition, the alert signal may comprise a wireless signal transmitted to an external device, such as a user's mobile device. The fault action may be different to fault action carried out when flow is detected during a fill operation.

[0028] The method may comprise measuring flow using one, more than one, or all of these flow sensors. It will be understood that measuring the flow involves determining quantitative information about the flow, rather than simply the presence or absence of flow.

[0029] In some embodiments, the flow control arrangement further comprises a drain valve, the drain valve arranged between the system outlet pipe and the drain, the drain valve moveable between an open position in which fluid is able to flow through the drain valve, and a closed position, in which fluid is prevented from flowing through the drain valve. By providing this drain valve, it is possible to selectively control when the drain is closed and when it is open, and to close the drain such that fluid supplied through the inlet pipe cannot exit through the drain and must therefore flow elsewhere, i.e., out of the system outlet pipe.

[0030] It will be understood that by the drain valve being arranged between the system outlet pipe and the drain there is a path from the system outlet pipe to the drain and the drain valve is located along that path. Said path does not have to define a direction of flow of the fluid through the pressure fill device. It also does not need to be a direct path, i.e. other intervening components could be connected between the system outlet pipe and the drain. For example, the system outlet pipe and the drain valve may each be connected to a manifold, such that there is a path from the system outlet pipe to the drain that passes through both the manifold and the drain valve.

[0031] In some embodiments, the drain valve is a solenoid valve.

[0032] In some embodiments, the drain valve is biased into an open position. By this it will be understood that when not actuated or moved by an external force, the drain valve is by default in the open position (i.e., the position in which the valve allows flow out of the drain). The drain valve must therefore be controlled or actuated to move to the closed position, preventing flow.

[0033] If only the outlet fluid flow sensor is present it may not be possible to fully determine that a fault is due to failure of the drain valve (as opposed to failure of the inlet valve to open), but nonetheless the outlet fluid flow sensor usefully indicates that a pressure fill operation is not being carried out successfully, and allows the pressure fill operation to be ceased so that the fault can be investigated.

[0034] Thus, in some embodiments, the method comprises initiating a fault action responsive to detecting that fluid is not flowing through the system outlet pipe, during a time when the pressure fill device is carrying out a fill operation. The fault action may comprise the pressure fill device ceasing the fill operation. In addition, or alternatively, the fault action may comprise outputting an alert signal. The alert signal may be an audible or visual signal. The audible or visual signal may be simple, e.g. a siren sound or flashing light, or it may have informational content, e.g. a spoken or written message containing information about the fault. Alternatively, the alert signal may be a wireless signal transmitted to an external device, such as a user's mobile device.

[0035] In some embodiments, the pressure fill device comprises both the inlet fluid flow sensor and the outlet fluid flow sensor. Providing both the inlet fluid flow sensor and the outlet fluid flow sensor allows further useful information to be derived from the combination of data output by both sensors. For example, by comparing the flow of fluid detected through the inlet pipe with the flow of fluid detected through the system outlet pipe, a measure of fluid wastage can be determined.

[0036] Thus, in some embodiments, the method comprises detecting fluid wastage by comparing the flow of fluid detected through the inlet pipe and the flow of fluid detected through the system outlet pipe. This would allow a user of the pressure fill device to track the amount of

fluid wasted by the pressure fill device.

[0037] The flow sensors may measure flow, i.e. determine quantitative information about the flow, e.g. the rate of flow. Where the diameter of the inlet pipe and the system outlet pipe, respectively, are known, the flow rate determined by each sensor can be converted to give a flow rate in units of volume per second, e.g. cm³/s. From this, a total volume of fluid lost in a selected time period may be calculated (e.g., by integration) The volume of fluid lost can then be calculated by subtracting the volume of fluid that has passed out through the system outlet pipe, from the volume of fluid that has passed through the system inlet pipe, since the fluid that has not flowed out through the system outlet pipe must have passed out through the drain (and therefore been wasted). Thus, in some embodiments, the method comprises detecting fluid wastage by subtracting the flow of fluid (e.g. a volume of fluid flowing in a defined time period) detected through the system outlet pipe from the flow of fluid (e.g. a volume of fluid flowing in a defined time period) detected through the inlet pipe.

[0038] The presence of both the inlet fluid flow sensor and the outlet fluid flow sensor is furthermore useful since it allows the pressure fill device to identify whether a fault has occurred with the inlet valve, or the drain valve, in the event that a fill operation fails. If no flow is detected through the outlet fluid flow sensor during a flow operation this could be indicative of a failure of either the inlet valve or the drain valve. If no flow is detected through the inlet fluid flow sensor then the fault must be (at least) with the inlet valve, but if no flow is detected through the outlet fluid flow sensor and the inlet fluid flow sensor indicates flow through the inlet pipe then it can be determined that the actuation of the drain valve to the closed position has failed since it has not closed to prevent flow through the drain and therefore enable flow through the system outlet pipe. Thus, the method may further comprise:

detecting flow of fluid through an inlet pipe using an inlet fluid flow sensor, the inlet pipe arranged to be connected, in use, to a fluid supply;
detecting flow of fluid through a system outlet pipe using an outlet fluid flow sensor, the system outlet pipe arranged to be connected, in use, to a closed-loop fluid circulation system; and
determining, based on detecting the flow of fluid through both the inlet pipe and the system outlet pipe, whether a fault of the drain valve has occurred.

[0039] In some embodiments, the flow control arrangement is arranged between the inlet pipe and the system outlet pipe. It will be understood that by this it is meant that the flow control arrangement is located on (or within) a path (not necessarily the fluid flow path) which passes from the inlet pipe to the system outlet pipe.

[0040] In some embodiments, the flow control arrangement further comprises a manifold, wherein the inlet pipe comprises a first end, connected to the manifold, and

wherein the system outlet pipe comprises a first end, connected to the manifold. The manifold may comprise (e.g., at certain times during operation of the pressure fill device) an air gap. This air gap may help to prevent contamination of the fluid supply by the fluid within the fluid circulation system. The manifold may be made of any suitable material. For example, the manifold may be a brass manifold or a plastic manifold (e.g. a moulded plastic manifold).

[0041] Although various separate components are described here, it will be appreciated that one or more of these components may be integrally formed, e.g. provided as a single integral component. Such a component may be more readily moulded, e.g. by injection moulding. For example, the manifold may be integrally formed with an inlet pipe and/or an outlet pipe and/or a drain pipe. The integral manifold may have mounting points into which the one or more flow control valves can be mounted. In some examples, parts of the flow control valves such as the inlet and outlet flow paths and the seal seat may be formed integrally with the manifold and/or with the inlet pipe and/or outlet pipe and/or drain pipe.

[0042] In some embodiments, the first end of the inlet pipe is connected to the manifold at a first position, wherein the first end of the system outlet pipe is connected to the manifold at a second position, and wherein the first position is above the second position. It will be understood that by the first position being above the second position it is meant that when the pressure fill device is oriented in its normal operating orientation (e.g. in its operating position, mounted on a wall), the first position is at a higher up position, along a vertical axis, than the second position. This of course does not require the first position to be directly vertically above the second position. This arrangement helps to reduce the contamination risk. Provided that the drain valve is open, fluid will never build up to the level of the inlet pipe. This reduces the risk of contaminating the fluid supply (which may be a mains fluid supply) that is connected to the inlet pipe with the system fluid. This air gap provides a further level of contamination protection in addition to any check valves installed in the inlet pipe and the outlet pipe.

[0043] The drain valve may be arranged specifically between the manifold and the drain. Thus, in some embodiments, the flow control arrangement further comprises a drain, and a drain valve, the drain valve arranged between the manifold and the drain, the drain valve moveable between an open position in which fluid is able to flow through the drain valve, and a closed position, in which fluid is prevented from flowing through the drain valve.

[0044] In some embodiments, the inlet pipe comprises a back-flow prevention valve (e.g., a double check valve). This helps to prevent fluid flowing into the inlet pipe from downstream parts of the pressure fill device, such as the manifold, the system outlet pipe, and the drain. This therefore helps to prevent contamination of a fluid supply connected to the inlet pipe. This may make it safe for a

mains water supply to be used as the fluid supply, since contamination of the mains water supply is prevented.

[0045] In some embodiments, the method comprises detecting a direction of flow through the inlet fluid flow sensor, and, responsive to detecting that the direction of flow is opposite to the expected direction, determining that a back-flow prevention valve of the inlet pipe has failed. The method may further comprise initiating a fault action responsive to detecting that the direction of flow through the inlet fluid flow sensor is opposite to the expected direction.

[0046] In some embodiments, the system outlet pipe comprises a back-flow prevention valve (e.g., a double check valve). This helps prevent fluid flowing out of the outlet pipe, back into upstream parts of the pressure fill device, such as the manifold, the inlet pipe, and the drain. This therefore helps to prevent loss of fluid from a fluid circulation system connected to the system outlet pipe even in the event that the pressure in the fluid circulation system is higher than the pressure in the pressure fill device. This furthermore helps to prevent contamination of a fluid supply connected to the inlet pipe, since no fluid is able to pass into the manifold from the fluid circulation system, and therefore no fluid is at risk of then passing back into the fluid supply. This may make it safe for a mains water supply to be used as the fluid supply, since contamination of the mains water supply is prevented.

[0047] In some embodiments, the method comprises detecting a direction of flow through the outlet fluid flow sensor, and, responsive to detecting that the direction of flow is opposite to the expected direction, determining that a back-flow prevention valve of the system outlet pipe has failed. The method may further comprise initiating a fault action responsive to detecting that the direction of flow through the outlet fluid flow sensor is opposite to the expected direction.

[0048] In some embodiments, the pressure fill device comprises a pressure sensor connected to the inlet pipe. In some embodiments, the pressure fill device comprises a pressure sensor connected to the system outlet pipe.

[0049] The method may comprise controlling the fill operation (e.g., when to initiate a fill operation and/or when to cease a fill operation) based at least in part (optionally exclusively) on data from a pressure sensor connected to the inlet pipe and/or a pressure sensor connected to the system outlet pipe.

[0050] Additionally, or alternatively, the method may comprise controlling the fill operation (e.g., when to initiate a fill operation and/or when to cease a fill operation) based at least in part (optionally exclusively) on data from the inlet fluid flow sensor and/or the outlet fluid flow sensor.

[0051] In some embodiments, the pressure fill device is arranged to selectively produce a supply of fluid from the fluid supply to the system outlet pipe without the use of a pump (i.e. using only the pressure present in the fluid supply). In other embodiments, the pressure fill device further comprises a pump, and optionally also comprises

a break tank upstream of the pump, wherein the pressure fill device is arranged to selectively produce a supply of fluid from the fluid supply to the system outlet pipe using the pump, and optionally also the break tank.

[0052] The system outlet pipe may be arranged to be connected, in use, to a fluid circulation system, e.g. a closed-loop fluid circulation system. Thus, according to a sixth aspect of the present invention, there is provided a fluid circulation arrangement comprising:

a fluid circulation system; and

a pressure fill device having any of the features described above, wherein the system outlet pipe of the pressure fill device is connected to the fluid circulation system.

[0053] In some embodiments, the fluid circulation system is a closed-loop fluid circulation system.

[0054] In some embodiments, the fluid circulation arrangement further comprises a fluid supply, wherein the inlet pipe of the pressure fill device is connected to the fluid supply. The fluid supply may be a mains water supply.

[0055] The fluid circulation system may be for heating or chilling domestic or non-domestic premises.

[0056] The fluid circulated within such heating or chilling systems may include an additive, to enhance its ability to provide a heating or chilling effect, or to affect the properties of the fluid, such as its freezing point. Where additional fluid is introduced to the fluid circulation system it may also be necessary to introduce additional additive, so that the ratio of additive to total volume of fluid is maintained. For this purpose, the fluid circulation arrangement may further comprise an additive supply system, arranged to introduce additive into the fluid circulating within the fluid circulation system. The additive supply system may be arranged to determine an amount of additive to be introduced to the fluid circulating in the fluid circulation system based at least in part in data collected from the outlet fluid flow sensor of the pressure fill device. This may help an accurate amount of additive to be introduced, since the reading on the outlet fluid flow sensor of the pressure fill device is indicative of the volume of fluid added to the fluid circulation system.

[0057] Thus, in some embodiments, the method further comprises, calculating an amount of additive to introduce into fluid circulating in a fluid circulation system, based (at least in part) on data output by the output fluid flow sensor of the pressure fill device.

[0058] Features of any aspect or embodiment described herein may, wherever appropriate, be applied to any other aspect or embodiment described herein. Where reference is made to different embodiments or sets of embodiments, it should be understood that these are not necessarily distinct but may overlap.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] Certain preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a front view showing components of a pressure fill device according to an aspect of the present invention;

Figure 2 is a schematic drawing showing a fluid circulation arrangement including a pressure fill device as shown in Figure 1;

Figure 3 is a flow diagram illustrating stages of the operation of the pressure fill device of Figure 1;

Figure 4 is a front view showing components of a pressure fill device according to another aspect of the present invention; and

Figure 5 is a front view showing components of a pressure fill device according to another aspect of the present invention.

DETAILED DESCRIPTION

[0060] Figure 1 shows a pressure fill device 1. The pressure fill device 1 includes an inlet pipe 2, arranged to be connected, in use, to a fluid supply 3. The pressure fill device 1 also includes a system outlet pipe 4, arranged to be connected, in use, to a closed-loop fluid circulation system 5.

[0061] The pressure fill device 1 also includes a flow control arrangement 6, arranged to selectively enable supply of fluid from the fluid supply 3 to the system outlet pipe 4. The pressure fill device 1 is arranged to selectively produce a supply of fluid from the fluid supply 3 to the system outlet pipe 4 without the use of a pump, and using only the pressure of the fluid supply 3.

[0062] The flow control arrangement 6 includes an inlet pipe valve 12, which in this example is a solenoid valve. The inlet pipe valve 12 is moveable between an open position in which fluid is able to flow through the inlet pipe valve 12, and a closed position, in which fluid is prevented from flowing through the inlet pipe valve 12. In this example the inlet pipe valve 12 is located adjacent to the end of the inlet pipe 2, as shown in Figure 1. The inlet pipe valve 12 is biased towards the closed position, such that by default flow through the inlet pipe valve 12 is prevented and the valve must be actuated to allow flow through the inlet pipe 2.

[0063] The flow control arrangement 6 further includes a drain valve 14, connected to the drain 16. The drain 16 allows fluid to flow out of the pressure fill device 1 (without flowing into the fluid circulation system 5 connected to the system outlet pipe 4).

[0064] The flow control arrangement 6 further includes a manifold 18. A first end of the inlet pipe 20 is connected to the manifold at a first position. A first end of the system outlet pipe 22 is connected to the manifold at a second position. The first position is higher than the second po-

sition, as seen in Figure 1. As seen it is the second ends of the inlet pipe 2 and the system outlet pipe 4 (i.e. the ends opposite to the first ends) that are connected, respectively, to the fluid supply 3 and the fluid circulation system 5.

[0065] The drain valve 14 is arranged between the manifold 18 and the drain 16. The drain valve 14, which in this example is a solenoid valve, is moveable between an open position in which fluid is able to flow through the drain valve 14, and a closed position, in which fluid is prevented from flowing through the drain valve 14. The drain valve 14 is biased towards the open position, in which flow is enabled, such that by default fluid passing out of the inlet pipe 2 will flow through the manifold 18 and out of the drain 16. When the drain valve 14 is closed, fluid instead remains in the manifold 18 and then passes into the system outlet pipe 4, and therefore out into the fluid circulation system 5.

[0066] The pressure fill device 1 further includes an inlet fluid flow sensor 8, arranged to detect flow through the inlet pipe 2, and an outlet fluid flow sensor 10, arranged to detect flow through the system outlet pipe 4.

[0067] A first back-flow prevention valve 24 is located upstream of the inlet valve 12. In this example, the first back-flow prevention valve 24 is a double-check valve.

[0068] A second back-flow prevention valve 26 is located at the first end 22 of the system outlet pipe 2. In this example, the second back-flow prevention valve 26 is a double-check valve.

[0069] A first pressure sensor 28 is connected to the inlet pipe 2. A second pressure sensor 30 is connected to the system outlet pipe 4. The parts shown as "pressure sensors" in Figure 1 may in fact be connections to which additional circuitry or sensors are fitted to provide pressure sensing functionality.

[0070] Figure 2 is a schematic drawing showing a fluid circulation arrangement 100 including a pressure fill device 1 as shown in Figure 1. The inlet pipe 2 is shown, as is the fluid supply 3 to which it is connected. Similarly, the closed-loop fluid circulation system 5 is shown, which is connected to the system outlet pipe 4.

[0071] In this example the closed-loop fluid circulation system 5 is a system for heating or chilling domestic or non-domestic premises. In this example an additive is introduced into the fluid circulating within the closed-loop fluid circulation system 5. For this purpose, an additive supply system 102 is provided, connected to the closed-loop fluid circulation system 5, and arranged to introduce a quantity of additive into the fluid circulating within the closed-loop fluid circulation system 5.

[0072] The additive supply system 102 is arranged to determine an amount of additive to be introduced to the fluid circulating in the fluid circulation system based at least in part in data collected from the outlet fluid flow sensor 10 (and optionally also the inlet fluid flow sensor 8). The additive supply system 102 may be connected to the fluid flow sensor 10 to receive this information, it may be connected to a controller of the pressure fill de-

vice 1 (not shown), or it may be arranged to receive the sensor data wirelessly. Using data from the outlet fluid flow sensor 10 helps the additive supply system 102 to introduce an accurate quantity of additive such that the ratio of fluid to additive remains within a desired range.

[0073] Figure 3 is a flow diagram illustrating stages of the operation of the pressure fill device of Figure 1.

[0074] At a first stage 100, it is detected, by pressure sensor 30, that pressure within the fluid circulation system 5 has dropped below a threshold pressure value (optionally for at least a threshold period of time). Responsive to this, a controller (not shown) of the pressure fill device 1, begins a pressure fill operation by moving to stage 102.

[0075] At stage 102, the inlet pipe valve 12 is opened, and the drain valve 14 is closed. As a result, fluid flows into the inlet pipe 2 from the fluid supply 3, through the first back-flow prevention valve 24, the inlet valve 12 and the manifold 18. Then, since the drain valve 14 is closed, the fluid flows through the second back-flow prevention valve 26, into the system outlet pipe 4, and out into the fluid circulation system 5, increasing pressure in the fluid circulation system 5. This occurs as a result of the pressure in the fluid supply 3 (e.g. a mains water supply) being higher than the pressure in the fluid circulation system 5. The pressure fill device 1 may check that the pressure in the fluid supply 3 is above a threshold amount, using the pressure sensor 28 connected to system inlet pipe 2, before starting the fill operation, to make sure that the pressure is sufficient to achieve filling as desired.

[0076] During the fill operation stage 102, the pressure fill device 1 monitors for failures or faults with the device, as shown at stage 110. This stage is shown in dashed lines since it does not follow step 102 but is rather carried out concurrently.

[0077] During monitoring 110, the pressure fill device 1 can detect failure of the drain valve 14 if no flow is detected in the system outlet pipe 4 (and flow is detected in the system inlet pipe 2). It can also detect failure of the inlet valve 12 (i.e., failure to actuate to the open position, such that it has "failed shut") if no flow is detected through the inlet pipe 2. If a fault is detected the pressure fill device (e.g. the controller), initiates a fault action, such as ceasing the fill operation by closing the inlet valve 12 and opening the drain valve 14.

[0078] At stage 104 it is detected, by pressure sensor 30, that the desired pressure has been achieved.

[0079] Once the required system pressure is achieved, (and possibly after a set time period has passed following this pressure being reached, during which filling is continued) the inlet valve 12 is closed again by the controller (not shown), stopping fluid from flowing out from the fluid supply 3 into the inlet pipe 2. This is stage 108 shown in Figure 3. At the same time, the drain valve 14 is opened. This allows fluid that is positioned between the inlet valve 12 and the drain valve 14 to flow out to the drain 16, creating an air gap within the manifold 18.

[0080] While it is at stage 108 (a time when the pres-

sure fill device is not carrying out a fill operation), the pressure fill device 1 monitors for failures or faults with the device. This stage is shown in dashed lines since it does not follow step 108 but is rather carried out concurrently.

[0081] During monitoring 112, the pressure fill device 1 can detect failure of the inlet valve 12 to return (or remain in) the closed position if flow is detected through the inlet pipe 2 using the inlet fluid flow sensor 8, since there should be no flow into the pressure fill device 1 outside of a time when a fill operation is being carried out. If a fault is detected the pressure fill device (e.g. the controller), initiates a fault action, such as outputting an alert signal. The pressure fill device 1 may further comprise a transmission portion (not shown) arranged to transmit a wireless signal to an external device, such as a mobile phone, where the wireless signal includes the alert signal. This may alert a user that a valve within the pressure fill device 1 has failed.

[0082] The pressure fill device 1 then remains at this stage 108, until a drop in pressure to below the threshold is detected, moving the device back to stage 100 in Figure 3, and beginning the cycle again. In other words, the cycle described above is repeated as and when the fluid circulation system 5 requires its pressure to be topped up.

[0083] Both during a fill operation, and not during a fill operation (e.g., continually) the pressure fill device monitors fluid wastage by the device, as stage 114. The device monitors for fluid wastage by comparing the flow of fluid detected through the inlet pipe and the flow of fluid detected through the system outlet pipe.

[0084] Figure 4 shows another example of a pressure fill device 1'. This pressure fill device 1' contains many of the same components as the example of Figure 1. These like components are labelled with the same reference numerals, but followed by an apostrophe, i.e. a pressure fill device 1', rather than a pressure fill device 1 in Figure 1. These like components will not be described here again.

[0085] However, the pressure fill device 1' of this example does not contain the inlet flow sensor or the outlet flow sensor that are included in the example of Figure 1, but does instead contain a drain flow sensor 9' arranged between the drain valve 14' and the drain 16'. It is arranged to monitor how much fluid is drained out of the drain 16', and therefore wasted by the pressure fill device 1'.

[0086] This drain flow sensor 9' can also be used to monitor for faults with the pressure fill device 1'. For example, if a fill operation is in progress but flow is detected through the flow sensor 9', this indicates that the drain valve 14' has failed to close as intended, and that therefore the fill operation is not achieving filling of the fluid circulation system, as intended. Alternatively, if no fill operation is in progress but flow is detected through the drain valve 14' then this may be indicative of some fault within the pressure fill device 1', for example failure of the inlet valve 12' (into the open position) or failure of the

back-flow prevention valve 26'. This may be particularly advantageous since all of this useful information may be obtained using only a single flow sensor.

[0087] However, it will be appreciated that this drain flow sensor 9' may also be used in combination with the inlet flow sensor and/or the outlet flow sensor as described above in relation to the example of Figure 1. This is illustrated in the third example of a pressure fill device 1" which is shown in Figure 5. It contains both an inlet flow sensor 8", an outlet flow sensor 10" and a drain flow sensor 9". All other components that are the same as the previous examples have been labelled with the same reference numerals but followed by two apostrophes, compared to the example of Figure 1.

[0088] It will be appreciated by those skilled in the art that the invention has been illustrated by describing one or more specific embodiments thereof, but is not limited to these embodiments; many variations and modifications are possible, within the scope of the accompanying claims.

Claims

1. A pressure fill device, comprising:

an inlet pipe, arranged to be connected, in use, to a fluid supply;
a system outlet pipe;
a flow control arrangement, arranged to selectively enable supply of fluid from the fluid supply to the system outlet pipe;
the device further comprising at least one of:

an inlet fluid flow sensor, arranged to detect flow through the inlet pipe; and
an outlet fluid flow sensor, arranged to detect flow through the system outlet pipe.

2. The pressure fill device of claim 1, comprising both the inlet fluid flow sensor and the outlet fluid flow sensor.

3. The pressure fill device of claim 1 or 2, wherein the flow control arrangement further comprises an inlet pipe valve moveable between an open position in which fluid is able to flow through the inlet pipe valve, and a closed position, in which fluid is prevented from flowing through the inlet pipe valve; optionally wherein the inlet pipe valve is a solenoid valve.

4. The pressure fill device of claim 3, wherein the inlet pipe valve is biased into a closed position.

5. The pressure fill device of any preceding claim, wherein the flow control arrangement further comprises a drain, and a drain valve, the drain valve arranged between the system outlet pipe and the drain,

the drain valve moveable between an open position in which fluid is able to flow through the drain valve, and a closed position, in which fluid is prevented from flowing through the drain valve; optionally

wherein the drain valve is a solenoid valve; and/or
wherein the drain valve is biased into an open position.

6. The pressure fill device of any preceding claim, wherein the flow control arrangement further comprises a manifold, wherein the inlet pipe comprises a first end, connected to the manifold, and wherein the system outlet pipe comprises a first end, connected to the manifold; optionally wherein the first end of the inlet pipe is connected to the manifold at a first position, wherein the first end of the system outlet pipe is connected to the manifold at a second position, and wherein the first position is above the second position.

7. The pressure fill device of any preceding claim, further comprising a pressure sensor connected to the inlet pipe and/or further comprising a pressure sensor connected to the system outlet pipe.

8. The pressure fill device of any preceding claim, wherein the pressure fill device is arranged to selectively produce a supply of fluid from the fluid supply to the system outlet pipe without the use of a pump.

9. The pressure fill device of any preceding claim, wherein the flow control arrangement further comprises a drain, arranged to drain fluid out of the pressure fill device, wherein the pressure fill device further comprises a drain flow sensor, arranged to detect flow through the drain.

10. A fluid circulation arrangement comprising:

a fluid circulation system; and
a pressure fill device having any of the features described above, wherein the system outlet pipe of the pressure fill device is connected to the fluid circulation system; optionally wherein the fluid circulation system is for heating or chilling domestic or non-domestic premises.

11. A method of operating a pressure fill device, the method comprising:

detecting flow of fluid through an inlet pipe using an inlet fluid flow sensor, the inlet pipe arranged to be connected, in use, to a fluid supply; and/or detecting flow of fluid through a system outlet pipe using an outlet fluid flow sensor, the system outlet pipe arranged to be connected, in use, to

a closed-loop fluid circulation system.

12. The method of claim 11, comprising initiating a fault action responsive to detecting flow of fluid through the inlet pipe during a time when the pressure fill device is not carrying out a fill operation; optionally wherein the fault action comprises outputting an alert signal. 5

13. The method of claim 11 or 12, comprising initiating a fault action responsive to detecting that fluid is not flowing through the system outlet pipe, during a time when the pressure fill device is carrying out a fill operation; optionally wherein the fault action comprises the pressure fill device ceasing the fill operation. 10 15

14. The method of any of claims 11 to 13, comprising detecting fluid wastage by comparing the flow of fluid detected through the inlet pipe and the flow of fluid detected through the system outlet pipe. 20

15. A pressure fill device, comprising:
 - an inlet pipe, arranged to be connected, in use, to a fluid supply; 25
 - a system outlet pipe;
 - a flow control arrangement, arranged to selectively enable supply of fluid from the fluid supply to the system outlet pipe, the flow control arrangement comprising a drain, arranged to drain fluid out of the pressure fill device; 30
 - the device further comprising a drain flow sensor, arranged to detect flow through the drain; optionally 35
 - wherein the drain flow sensor is arranged to measure the fluid flowing out of the drain.

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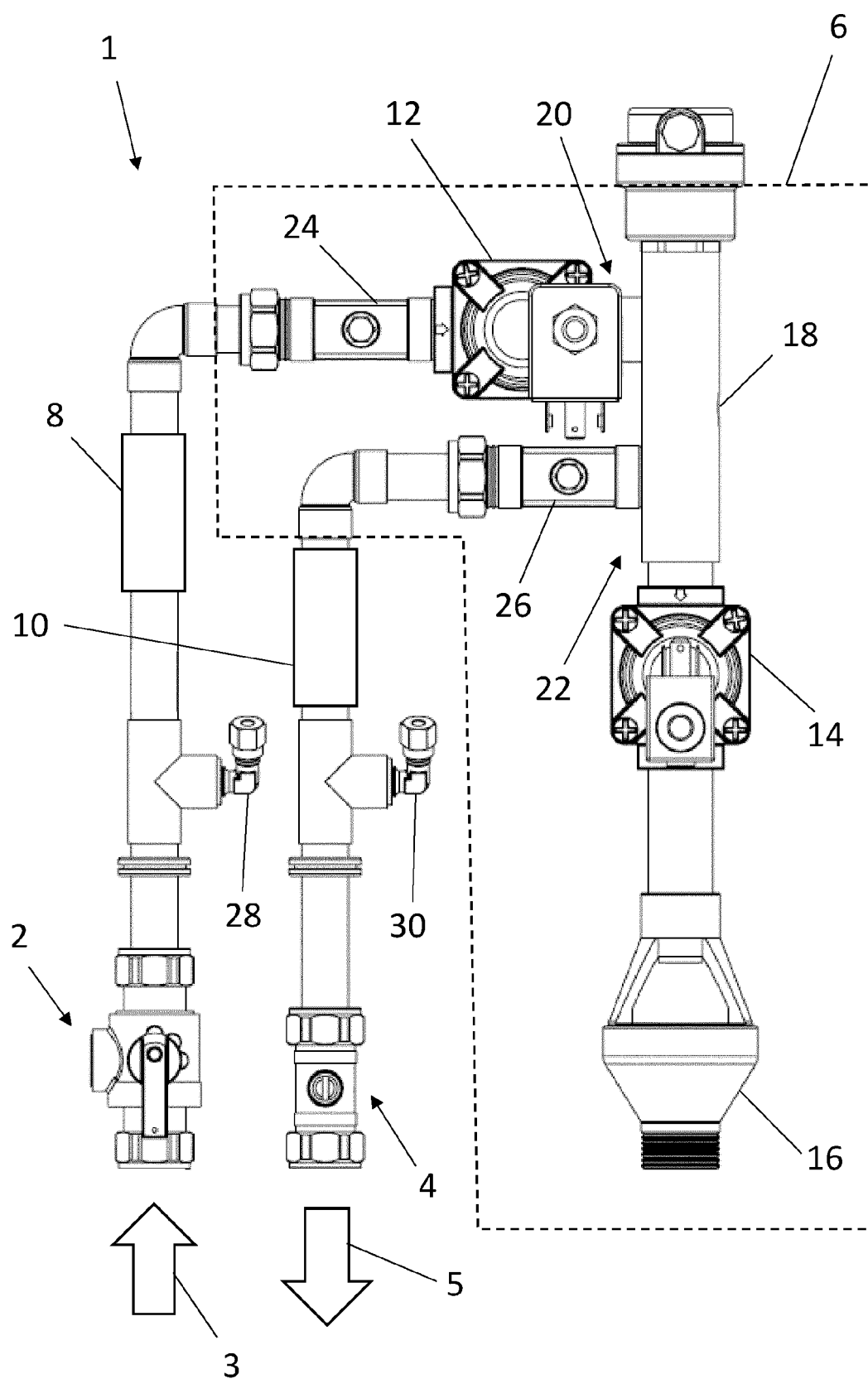


Figure 1

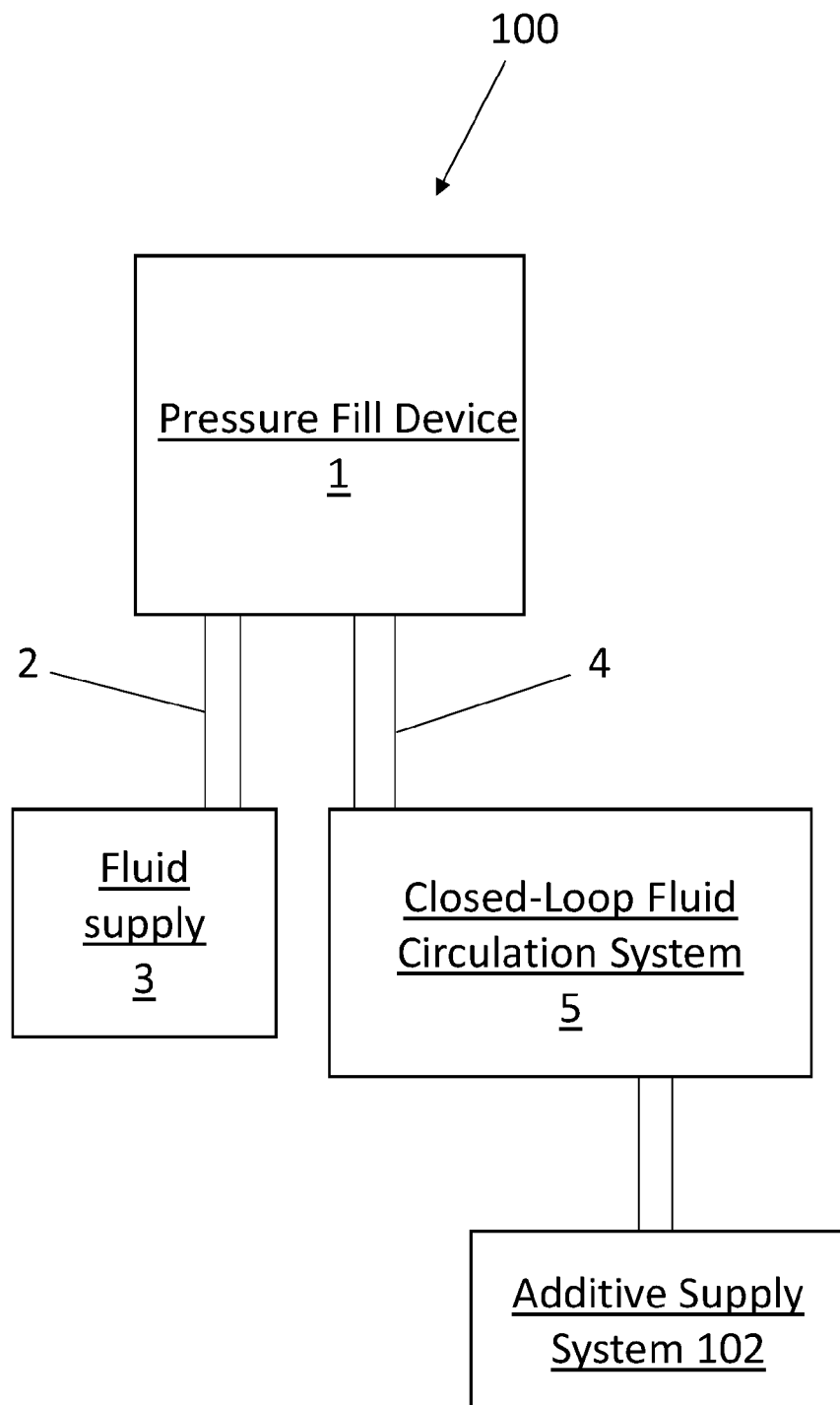


Figure 2

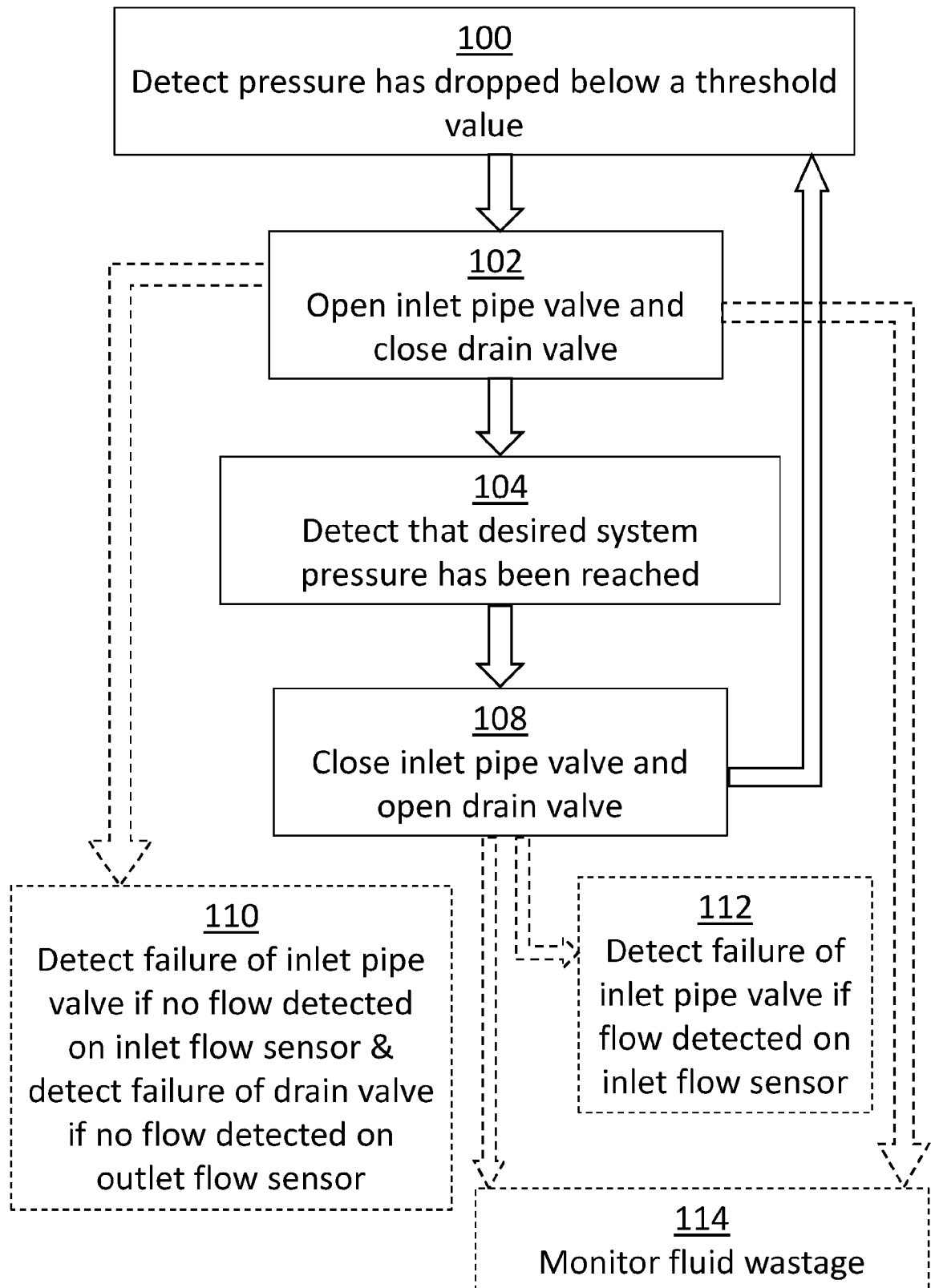


Figure 3

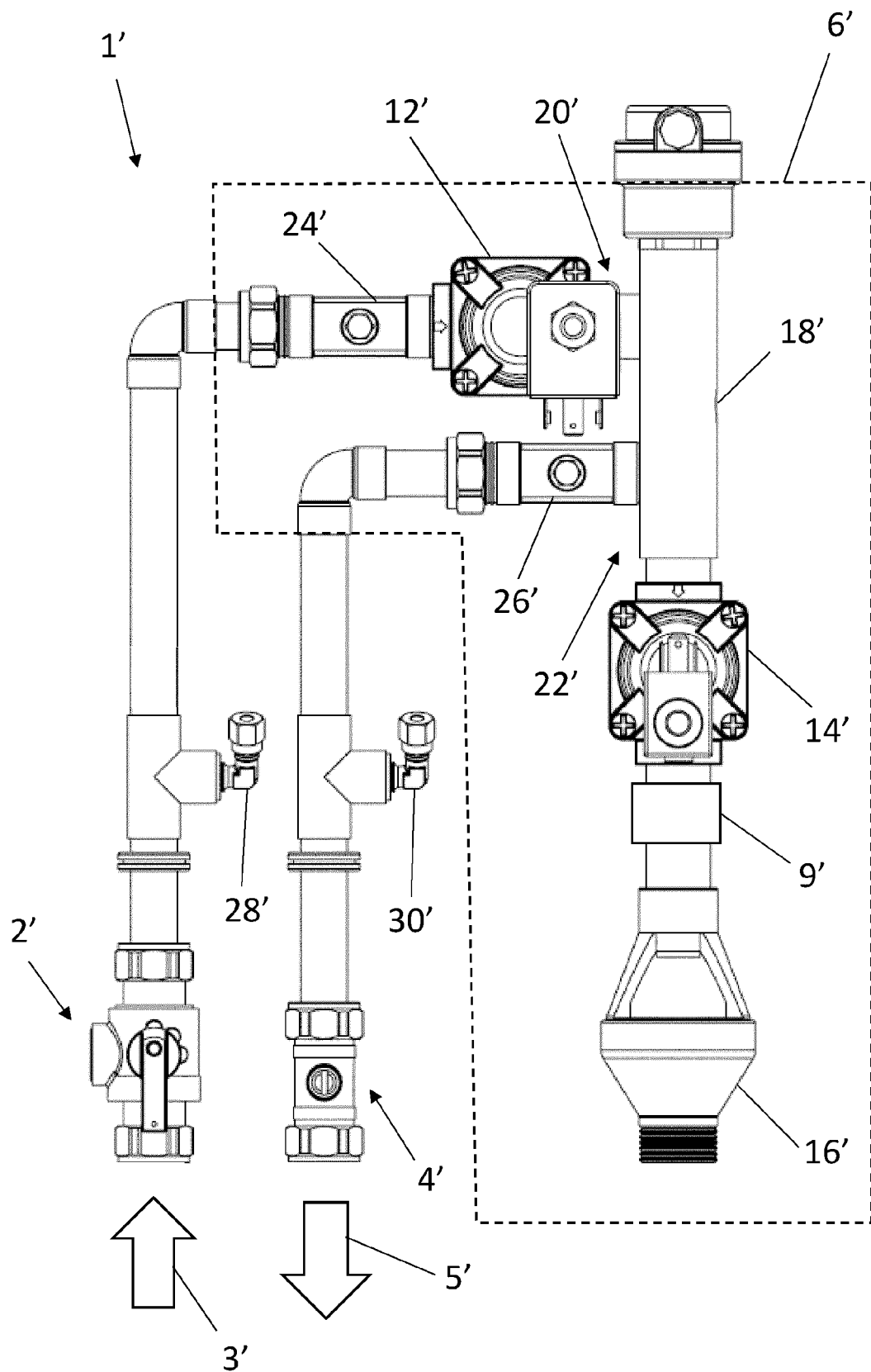


Figure 4

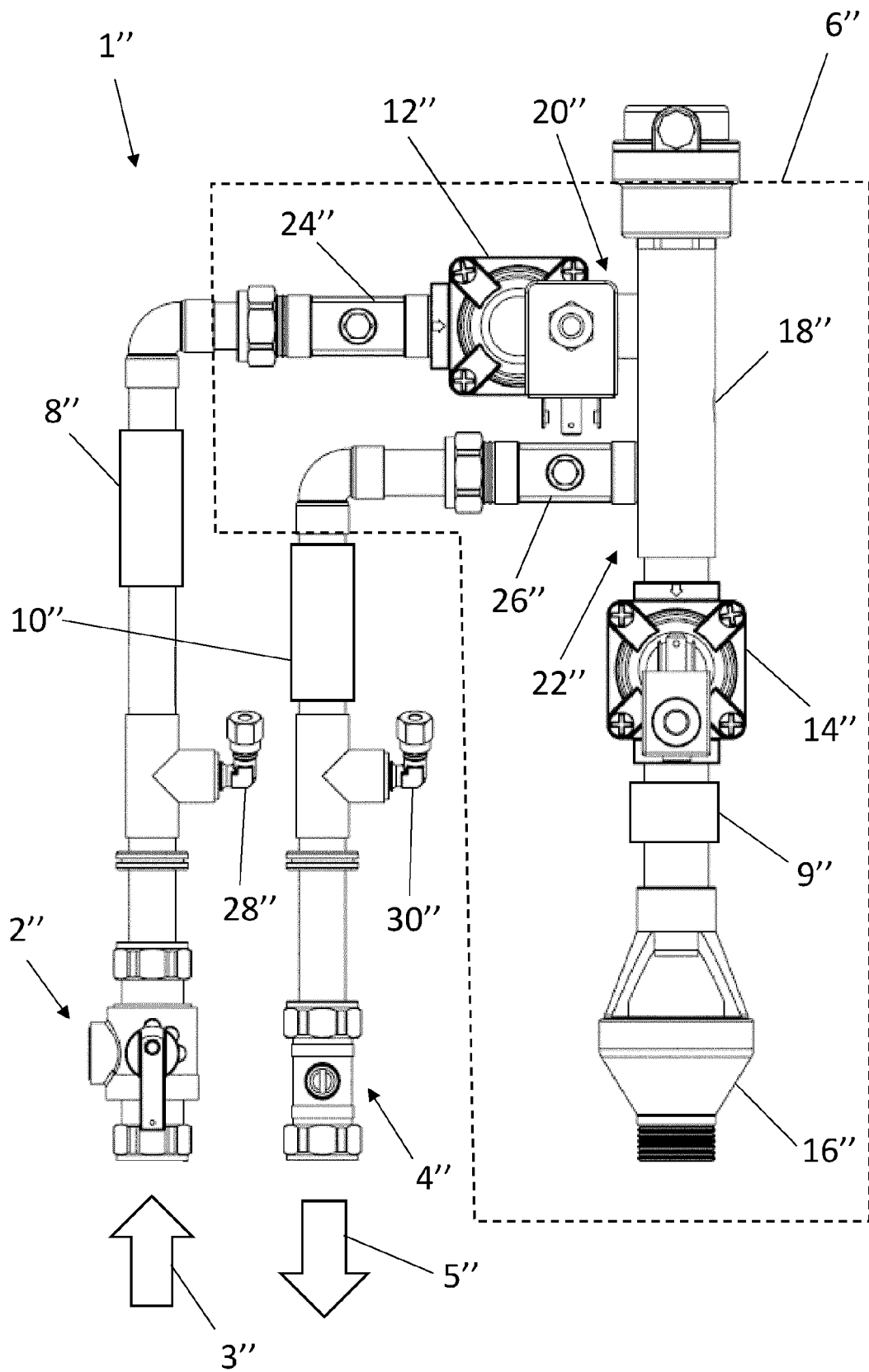


Figure 5



EUROPEAN SEARCH REPORT

Application Number

EP 24 16 3366

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Place of search Munich		Date of completion of the search 26 June 2024	Examiner García Moncayo, O
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	

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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