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(71) Applicant: **SPRINKLER ENERGY B.V.** [NL/NL]; Veerdijk 40 J, 1531 MS Wormer (NL).

(72) Inventors: **ATSMA, Ate**; c/o Veerdijk 40 J, 1531 MS Wormer (NL). **DE BRUIN, Ruben Udo**; c/o Veerdijk 40 J, 1531 MS Wormer (NL).

(74) Agent: **WITMANS, H.A.**; V.O., P.O. Box 87930, 2508 DH Den Haag (NL).

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(54) **Title:** HEAT TRANSFER SYSTEM

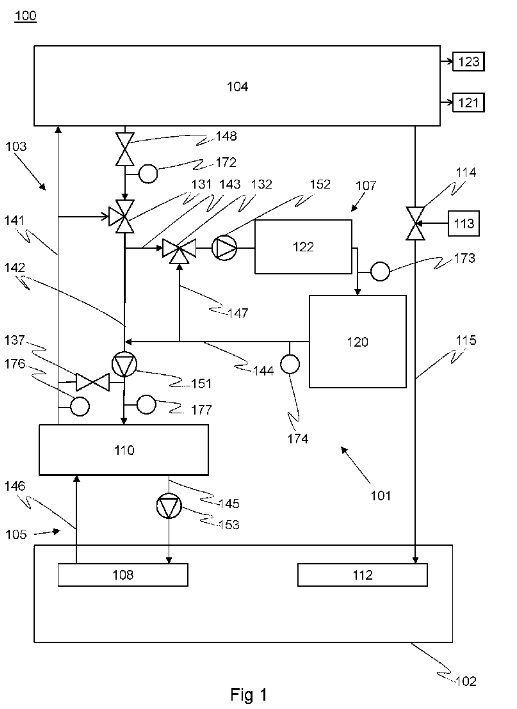

Fig 1

(57) **Abstract:** A thermal energy transfer arrangement is provided, comprising a building with a sprinkler system and a heat exchanger for heating the building. The arrangement further comprises a sprinkler reservoir arranged for holding a volume of water, wherein the sprinkler system is in fluid communication with the sprinkler reservoir and a thermal energy transfer system, comprising a primary heat pump, which is in fluid communication with the sprinkler reservoir and the heat exchanger, and which is arranged to transfer thermal energy from the sprinkler reservoir to the heat exchanger. By virtue of the arrangement, water in an existing sprinkler reservoir may be used as a source of thermal energy for heating the building.

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Title: Heat transfer system

TECHNICAL FIELD

The aspects and embodiments thereof relate to the technical fields of heat pumps and sprinkler systems.

BACKGROUND

Heat pumps are generally used to transfer thermal energy from a cooler medium to a warmer medium. For example, heat pumps are generally used to warm the interior buildings.

Common types of heat pumps are air source heat pumps, which use ambient air as a source of thermal energy, geothermal heat pumps, which use the ground as a source of thermal energy, and water source heat pumps, which use a volume of water as a source of thermal energy.

SUMMARY

It is preferred to provide for an improved heat transfer system for providing useful heat to one or more buildings, for example for warming the buildings or providing warm water. Such improvements may for example relate to the efficiency of the heat transfer system, a thermal capacity of the heat transfer system, and/or the amount of non-renewable source of energy used for the heating.

A first aspect provides a thermal energy transfer arrangement comprising a building comprising a sprinkler system and a heat exchanger for heating the building. The arrangement further comprises a sprinkler reservoir arranged for holding a volume of water, wherein the sprinkler system is in fluid communication with the sprinkler reservoir, and a thermal energy transfer system. The thermal energy transfer system comprises a primary heat pump, which is in fluid communication with the sprinkler reservoir and the heat exchanger, and which is arranged to transfer thermal energy from the sprinkler reservoir to the heat exchanger.

By virtue of the thermal energy transfer arrangement, thermal energy stored in the water of the sprinkler reservoir may be used for heating the building. This may allow for an energy efficient heating system, with a high thermal capacity by virtue of the size of the sprinkler reservoir. The amount of electrical energy required for operating the primary heat pump may be significantly lower than the amount of thermal energy withdrawn from the water in the sprinkler reservoir for heating the building. Furthermore, at least some of the electrical energy for operating the primary heat pump and/or an optional secondary heat pump preferably comes from a sustainable source, such as solar, water or wind.

In general, the term heat pump is used to describe a device which performs work in order to make thermal energy flow from a lower temperature to a higher temperature. The work required for the transfer is typically lower than the amount of thermal energy transferred. As such, a heat pump may be an efficient means for for example heating a building, compared to conventional heat sources such as natural gas.

In general, the term conduit is used for any object or element through which a fluid such as a liquid and/or a gas can be transported. A conduit may for example comprise a tube, pipe, hose, or a combination of sections of tubing, piping, or hosing. A single conduit may hence comprise multiple connected conduit sections, and one or more valves and/or pumps may be connected in a single conduit.

Furthermore in general, two objects being in fluid communication or being fluidly connected implies that a fluid can flow between the two objects. A fluid may comprise one or more liquids, one or more gasses, or any combination thereof. A fluid communication may be established by virtue of one or more conduits, and may be a direct fluid communication via a single conduit, or an indirect fluid communication via any number of conduits, valves, pumps, reservoirs, or any combination thereof. A closed valve between two objects may disable a fluid communication between said two objects.

In embodiments, the thermal energy transfer system further comprises a secondary heat pump, which is in fluid communication with the sprinkler reservoir and the ambient surroundings of the secondary heat pump, wherein the secondary heat pump is arranged to transfer thermal energy from the ambient surroundings to the sprinkler reservoir. As such, the secondary heat pump may be used to increase the temperature of water in the sprinkler reservoir, for example to prevent the temperature of the water to drop below 0 degrees C.

As a further option, when the thermal energy transfer system comprises the secondary heat pump, the thermal energy transfer arrangement further comprises a buffer reservoir in fluid communication with the sprinkler reservoir and the secondary heat pump, wherein the buffer reservoir is positioned downstream of the sprinkler reservoir and upstream of the secondary heat pump.

The thermal energy transfer arrangement may more in general comprise a buffer reservoir in fluid communication with the sprinkler reservoir, also when the thermal energy transfer arrangement does not comprise the secondary heat pump. The buffer reservoir is arranged for holding a buffer volume of water, which buffer volume of water may be used to circulate past the primary heat pump when there is insufficient water available from the sprinkler reservoir.

Additionally or alternatively, the thermal energy transfer arrangement may comprise a buffer reservoir in fluid communication with the primary heat pump, such that the primary heat pump may receive a fluid such as water from the buffer reservoir. Preferably, for example when water from the sprinkler reservoir is unavailable, the primary heat pump may return the fluid back to the buffer reservoir such that a closed circuit is obtained bypassing the sprinkler reservoir.

The thermal energy transfer system may further comprise a primary return conduit fluidly connecting the primary heat pump and the sprinkler reservoir, and a first three-way valve of which a first port is connected downstream of the sprinkler reservoir, a second port is connected upstream of the primary heat pump, and a third port is connected to the primary return conduit.

A three-way valve generally comprises three ports. By operating the three-way valve, for example by a system controller, fluid flow between three ports may be controller. In particular, a first port can be selectively fluidly connected with either a second port or a third port.

Embodiments of the thermal energy transfer system further comprise a secondary return conduit fluidly connecting the secondary heat pump and the sprinkler reservoir, and a second three-way valve, of which a first port is connected upstream of the secondary heat pump, a second port is connected to the secondary return conduit downstream of the secondary heat pump, and a third port is connected to the sprinkler reservoir.

As options, the sprinkler reservoir may be provided with a first fluid level sensor and a second fluid level sensor. The second fluid level sensor may be positioned above the first fluid level sensor. The first fluid level sensor may be comprised by the sprinkler system, whereas the second fluid level sensor may be added to the sprinkler system when the thermal energy transfer system is connected to the sprinkler reservoir.

For example in order to minimise the number of structural changes that have to be made to the sprinkler reservoir, the sprinkler reservoir may be in fluid communication with the thermal energy transfer system only via one fluid outlet out of the sprinkler reservoir, and/or one fluid inlet into the sprinkler reservoir. A low number of structural changes may be preferred in particular when retrofitting the thermal energy transfer system to an existing sprinkler reservoir.

A second aspect provides a thermal energy transfer system, which is in particular suitable for use in a thermal energy transfer arrangement according to the first aspect. It will be understood that options for the thermal energy transfer system disclosed in conjunction with the first aspect may be readily applied to a thermal energy transfer system according to the second aspect, and vice versa.

The thermal energy transfer system comprises a primary heat pump, a primary supply conduit, connected to the primary heat pump, for receiving water from the sprinkler reservoir, a primary return conduit connected to the secondary primary heat pump, for returning water to the sprinkler reservoir, wherein the primary heat pump is arranged to transfer thermal energy from a flow of water received from the primary supply conduit to a heat exchanger of a building.

As a particular option, the thermal energy transfer system further comprises a secondary heat pump, a secondary supply conduit connected to the secondary heat pump, for receiving water from the sprinkler reservoir, a secondary return conduit connected to the secondary heat pump, for returning water to the sprinkler reservoir. The secondary heat pump is arranged to transfer thermal energy from the ambient surroundings to water received from the secondary supply conduit.

The secondary heat pump may be connected in parallel to the primary supply conduit via the secondary supply conduit and the secondary return conduit. Alternatively, the secondary heat pump may be connected directly to the sprinkler reservoir via a secondary supply conduit and a secondary return conduit.

A third aspect provides method of operating a thermal energy transfer arrangement. The method may be particularly arranged for operating a thermal energy transfer arrangement according to the first aspect.

The method comprises circulating water through a primary circuit formed by a sprinkler reservoir, and a primary heat pump fluidly connected to the sprinkler reservoir via a primary supply conduit and a primary return conduit, operating the primary heat pump to extract thermal energy from the water circulating through the primary circuit, and supplying the extracted thermal energy to a heat exchanger of a building. By virtue of the method, thermal energy stored in water stored in a sprinkler reservoir can be used to heat a building.

Embodiments of the method may further comprise circulating water through a secondary circuit formed by a secondary heat pump fluidly connected to the sprinkler reservoir via a secondary supply conduit and a secondary return conduit, and operating the secondary heat pump to transfer thermal energy from a thermal energy source such as ambient air to water circulating through the secondary circuit. Any medium may be used as a thermal energy source, for example ambient air, ground, soil, underground water, or any other medium.

Preferably, the primary heat pump and the secondary heat pump may be operated simultaneously, to simultaneously and respectively withdraw and supply thermal energy to the sprinkler reservoir.

In general, the method according to the third aspect may be governed by a system controller. The method may further comprise, by the system controller, receiving a signal indicative of a water demand by a sprinkler system arranged for receiving water from the sprinkler reservoir, and in response to the signal, reducing or stopping a flow of water from the sprinkler reservoir to the primary heat pump. As such, the system controller may prevent or reduce the thermal energy system from withdrawing water from the sprinkler reservoir when said water is required by the sprinkler system, for example in case of a fire.

A fourth aspect provides a method of extracting thermal energy from water in a sprinkler reservoir, the method comprising the steps of connecting a primary supply conduit to the sprinkler reservoir for receiving water from the sprinkler reservoir, connecting a primary return conduit to the sprinkler reservoir for returning water to the sprinkler reservoir, receiving water from the sprinkler reservoir via the primary supply conduit by a primary heat pump, extracting thermal energy from the received water by the primary heat pump, and returning water to the sprinkler reservoir via the primary return conduit after the extracting of thermal energy from the received water by the primary heat pump.

A fifth aspect provides a method of transferring thermal energy to water in a sprinkler reservoir, the method comprising the steps of fluidly connecting a secondary supply conduit to the sprinkler reservoir for receiving water from the sprinkler reservoir, receiving water from the sprinkler reservoir via the secondary supply conduit by a secondary heat pump, by the secondary heat pump, transferring thermal energy from a heat source such as ambient air to the water received from the sprinkler reservoir, and returning the water to the sprinkler reservoir via a secondary return conduit.

The methods according to the fourth and fifth aspect may be executed simultaneously for the same sprinkler reservoir.

Since many sprinkler reservoir and sprinkler systems are already fitted to a building which has a heating demand, a thermal energy transfer system may be retro-fitted to said sprinkler reservoir and said building. For example, for the retro-fitting, the primary heat pump and/or secondary heat pump are fluidly connected to the sprinkler reservoir – preferably without affecting or interfering with the existing sprinkler system.

In any method disclosed herein, as an option, a fluid flow may be allowed between the sprinkler reservoir and the building, for the purpose of using fluid from the sprinkler reservoir for heating or cooling the building, in particular without requiring any further heat source or heat pump heating or cooling this fluid flow outside the sprinkler reservoir. For example, one or more heat sources may be used to heat fluid from the sprinkler reservoir to a temperature at which the fluid can be used to heat the building, in particular without having to use any heat pump. The fluid from the sprinkler reservoir can as such be directly supplied to the building and preferably returned back to the sprinkler reservoir after having been used to cool or heat the building. At the building, thermal energy can be extracted from the fluid or added to the fluid, depending on whether respectively heating or cooling of the building is preferred.

Additionally or alternatively, for any method disclosed herein, one or more heat sources may be used to directly heat fluid in the sprinkler reservoir. For example, this may be beneficial when costs of electricity used for heating are low or even negative. It will thus be appreciated that in any method disclosed herein, as an option, it is possible to transport fluid from the sprinkler reservoir to the building and preferably back again, for the purpose of using said fluid for heating and/or cooling the building. This fluid preferably bypasses one or more or all of the heat exchangers, heat pumps, sprinkler system, and buffer reservoir of the system, in any combination thereof.

BRIEF DESCRIPTION OF THE FIGURES

In the figures,

Fig. 1 shows a schematic representation of a thermal energy transfer arrangement

DETAILED DESCRIPTION

Fig. 1 shows a schematic representation of a thermal energy transfer arrangement 100 comprising a building 102, a sprinkler tank 104, and an embodiment of a heat transfer system 101. The sprinkler tank 104 is for example arranged for holding more than 100 m^3, more than 250 m^3, or even more than 600 m^3 of water, or any other liquid. The sprinkler tank 104 is generally positioned outside the building 102, and is an example of a sprinkler reservoir. In other examples, the sprinkler reservoir may be any volume of water, for example contained in an open water reservoir, such as an artificial or natural pool, pond, or lake. A sprinkler reservoir, such as a sprinkler tank, may be positioned inside a building, which may be the building 102 to the which thermal energy is transferred using the heat transfer system, or any other building.

The aim of the heat transfer system 101 is to provide useful heat to building 102, which may for example be a warehouse, industrial building such as a factory, agricultural building such as a warehouse for holding plants and/or animals, or a dwelling or apartment building. To operate or control different components of the heat transfer system 101 such as any combination of valves and pumps, the heat transfer system 101 comprises a system controller (not shown). The system controller may control the different valves and pumps in response to one or more sensor signals and/or user inputs.

For heating the building 102, the building 102 comprises one or more heat exchangers such as radiators, convectors, or any other heat exchangers arranged to transfer thermal energy for heating the building 102. The one or more heat exchangers are generally depicted as heat exchanger 108. In general, the heat exchanger 108 comprises a fluid input for receiving a fluid and a fluid output for outputting the fluid downstream of the fluid input. When thermal energy is transferred to the building 102 by the heat exchanger 108, the temperature of the fluid at the fluid output may be lower than the temperature of the fluid at the fluid input. In general, thermal energy may be transferred by virtue of convection, conduction, radiation, phase change, or any combination thereof.

The building 102 further comprise a sprinkler system, generally depicted as sprinkler 112. The sprinkler system may for example be an irrigation sprinkler system, for example for watering crops, or a fire sprinkler system for fire suppression comprising a plurality of fire sprinklers inside the building 102 and optionally one or more fire detectors such as smoke, heat or

CO_2 detectors. The sprinkler system 112 has a fluid input for receiving water from the sprinkler tank 104.

In the example of Fig. 1, the sprinkler system 112 is directly fluidly connected to the sprinkler tank 104 via sprinkler conduit 115. In the sprinkler conduit 115, a sprinkler valve 114 may be present, which may be controlled via a sprinkler controller 113. The sprinkler controller 113 may open or control the sprinkler valve 114, for example in response to a watering demand in case of an irrigation sprinkler system, or in response to a detected fire, in case of a fire sprinkler system. The sprinkler controller 113 may be independent from the system controller for controlling the thermal energy transfer system 101. For example, and in general, the thermal energy transfer system may be retro-fitted to an already existing building, sprinkler reservoir, and sprinkler system. Alternatively, the sprinkler system 112 may be indirectly fluidly connected to the sprinkler tank 104, in particular via one or more conduits or parts thereof of the thermal energy transfer system 101.

The thermal energy transfer system 101 shown in Fig. 1 comprises a primary heat pump 110, which may be a water-to-water heat pump. Water can be supplied from the sprinkler tank 104 to the primary heat pump 110 via a primary supply conduit 142. Water can be returned to the sprinkler tank 104 from the primary heat pump via a primary return conduit 141. In use, the temperature of the water flowing through the primary return conduit 141 may be lower than the temperature of the water flowing through the primary supply conduit 142.

The sprinkler tank 104, the primary supply conduit 142, the primary return conduit 141, and the primary heat pump 110 may be regarded as a primary circuit 103 through which water can be circulated. The primary supply conduit 142 is in Fig. 1 shown directly connected to the sprinkler tank 104. As an alternative option, the supply conduit 142 may be connected to the sprinkler conduit 115 for receiving water from the sprinkler tank 104.

However, a direct connection to the sprinkler tank 104 may be preferred to not possibly impede the working of the sprinkler system.

The primary heat pump 110 is further in fluid communication with the heat exchanger 108 of the building 102. In particular, a heat exchanger supply conduit 145 allows for transport of fluid from the primary heat pump 110 to the heat exchanger 108, and a heat exchanger return conduit 146 allows for transport of fluid from the heat exchanger 108 back to the primary heat pump 110. In use, the temperature of the fluid flowing through the heat exchanger return conduit 146 may be lower than the temperature of the water flowing through the heat exchanger supply conduit 145.

The primary heat pump 110, the heat exchanger 108, the heat exchanger supply conduit 145 and the heat exchanger return conduit 146 may together generally be regarded as a heat exchanger circuit 105 through which fluid, such as water, can be circulated.

The primary heat pump 110 may be connected to an electrical grid, battery, PV panel, wind turbine, any other source of electrical energy, or any combination thereof. Using the electrical energy, the primary heat pump 110 may transfer thermal energy between water supplied via the primary supply conduit 142 to the fluid returned via the heat exchange return conduit 146.

The thermal energy transfer system 101 shown in Fig. 1 further comprises an optional secondary heat pump 120. The secondary heat pump 120 is in the embodiment of Fig. 1 connected in parallel to the primary supply conduit 142, but may in other embodiments also be connected in parallel or in series to the primary return conduit 141. In particular, a secondary supply conduit 143 is used to transport water through towards the secondary heat pump 120, and a secondary return conduit 144 allows transport of water from the secondary heat pump 120 back towards the sprinkler 104, directly or indirectly.

The secondary heat pump 120, the secondary supply conduit 143, the secondary return conduit 144, the optional buffer 122 and a secondary bypass conduit 147 may together form a secondary circuit 107 for circulating water through – which circulation in particular may be allowed by the second three-way valve 132.

The secondary heat pump 120 may be connected to an electrical grid, battery, PV panel, wind turbine, any other source of electrical energy, or any combination thereof. Using the electrical energy, the secondary heat pump 120 may transfer thermal energy between ambient air to water flowing through the secondary heat pump 120.

In use, the primary heat pump 110 may thus be used to transfer thermal energy from water stored in the sprinkler tank 104 to the building 102. The optional secondary heat pump 120 may be used to transfer thermal energy from ambient air to the water stored in the sprinkler tank 104. In particular, the secondary heat pump 120 may be used when electrical energy is available, for example from one or more renewable energy sources such as PV-panels and/or wind turbines. In another example, the secondary heat pump 120 may be used when the temperature of the water in the sprinkler tank 104 drops below a desired threshold, for example below 5 degrees C, or below 1 degree C.

A sprinkler pump (not shown in Fig. 1) may be used to pump fluid, in particular water, from the sprinkler tank 104 to the sprinkler system 112. The sprinkler pump may be operable by the sprinkler controller 113, for example in response to a watering demand or in response to a detected fire.

The thermal energy transfer arrangement 100 depicted in Fig. 1 comprises an optional buffer reservoir 122. The buffer reservoir 122 is positioned upstream of the secondary heat pump 120, and downstream of the sprinkler reservoir 104, and in fluid communication with the secondary heat pump 120 and the sprinkler reservoir 104.

In general, the storage capacity of water of the buffer reservoir 122 may be lower than the storage capacity of the sprinkler reservoir 104. For example, the buffer reservoir 122 may be arranged for holding 1000 Litres or more of water, 3000 Litres or more, or even 5000 Litres or more of water.

As a further option shown in conjunction with the embodiment of the thermal energy transfer system 101 of Fig. 1, the system 101 comprises a first three-way valve 131 of which a first port is connected downstream of the sprinkler reservoir 104, a second port is connected upstream of the primary heat pump 110, and a third port is connected to the primary return conduit 141.

In a first operating mode of the first three-way valve 131, the first port and the second port are in fluid communication, allowing flow of water from the sprinkler tank 104 to the primary heat pump 110. In a second operating mode, the second port and the third port are in fluid communication, thereby by-passing the sprinkler tank 104 at least partially. The second operating mode may for example be used in case the shut-off valve 148 is closed. The second operating mode may in such case allow gradual shutting down of the thermal energy transfer system 101, for example in case of a water demand by the sprinkler system 112.

When the thermal energy transfer arrangement 100 comprises a buffer reservoir 122, water held in the buffer reservoir 122 may be circulated through the primary heat pump 110 and/or secondary heat pump 122 in case the shut-off valve 148 is closed to allow a gradual shut-down of the thermal energy transfer system 101.

As an even further option shown in conjunction with the embodiment of the thermal energy transfer system 101 of Fig. 1, the system 101 comprises a second three-way valve 132. Embodiments of the thermal energy transfer system 101 are envisioned comprising the only the first three-way valve, only the second three-way valve, or a combination of the first and second three-way valves.

A first port the second three-way valve 132 is connected to the secondary heat pump 120, in particular via the buffer reservoir 122, when present. A second port of the second three-way valve 132 is connected to the secondary return conduit 144, and a third port of the second three-way valve 132 is connected to the sprinkler tank 104, in particular via the primary supply conduit 142.

In the embodiment of Fig. 1, the second three-way valve 132 is connected upstream of the buffer reservoir 122, downstream of the secondary heat pump 120, and downstream of the sprinkler tank 104, in particular downstream of the first three-way valve 131.

In a first operating mode of the second three-way valve 132, the first port and the second port are in fluid communication, allowing circulating of water through the buffer reservoir 122 and the secondary heat pump 120.

In a second operating mode of the second three-way valve 132, the first port and the third port are in fluid communication, allowing water from the buffer reservoir 122 to flow back into the sprinkler tank 104. In use, the temperature of the water in the buffer reservoir 122 may be higher than a water temperature in the sprinkler reservoir 104, by virtue of the second heat pump 120. In general, weather influences such as ambient temperature and solar irradiation may increase or decrease the temperature of water in the sprinkler reservoir 104.

In other embodiments, a buffer bypass conduit may be present for feeding water from the buffer reservoir 122 back into the sprinkler tank 104 without passing through the second heat pump 120.

As a particular option, which may as other options be readily combined with other optional features disclosed herein, the embodiment of the thermal energy transfer arrangement 100 of Fig. 1 comprises a first fluid level sensor 121 and a second fluid level sensor 123. The second fluid level sensor 123 is positioned above the first fluid level sensor 121. As such, when a water level in the sprinkler 104 tank drops, first, the second fluid level sensor 123 may provide a sensor signal indicative of the water level dropping below a particular threshold. If the fluid level drops even further, the first fluid level sensor 121 may also provide a sensor signal indicative of the water level dropping below another particular threshold. The system controller may be arranged for receiving a sensor signal from the second fluid level sensor 123, from the first second fluid level sensor 121, or from both.

The first fluid level sensor 121 may be a sensor belonging to the sprinkler system 112, and may be used to provide a warning signal if the fluid level falls below a threshold value for the sprinkler system – for example in case of the sprinkler system 112 being activated, or by a leakage.

The second fluid level sensor 123 may be a sensor belonging to the thermal energy transfer system 101, and may for example indicate a leakage in any conduit or component of the thermal energy transfer system 101. In response to a sensor signal of the second fluid level sensor 123, the system controller may shut down the thermal energy transfer system 101 – in particular before the first fluid level sensor 121 detects the fluid level falling below the threshold associated with the sprinkler system 112. As such, it may be prevented that a leakage in the first fluid level sensor 121 negatively affects the sprinkler system 112.

A shut-off valve 148 may be used to close the primary supply conduit 142, for example by the sprinkler controller in response to a sensor signal from the second fluid level sensor 123 or directly in response to a sensor signal from the second fluid level sensor 123 without any action by the sprinkler controller. The shut-off valve 148 is preferably positioned upstream of the optional first three-way valve, upstream of the primary heat pump 110, upstream of the optional buffer reservoir 122, and upstream of the optional secondary heat pump 120. The shut-off valve 148 may be directly connected to the sprinkler tank 104. It may be preferred to have no other valves, pumps, and/or sensors upstream of the shut-off valve 148.

Any number of pumps may be comprised by the thermal energy transfer system 101. A number of examples of pumps are indicated in Fig. 1 and will elaborated on below. Any pump may be controllable by the system controller, for example based one or more sensor signals received by the system controller.

A primary flow pump 151 is positioned between the sprinkler reservoir 104 and the primary heat pump 110, and is arranged for constituting . In particular, the primary flow pump 151 is positioned in the primary supply conduit 142, downstream of the optional secondary return conduit 144.

A secondary flow pump 152 is depicted in Fig. 1, and is arranged for constituting a flow of water through the secondary heat pump 120. The secondary flow pump 152 may be positioned upstream of the secondary heat pump 120, and in particular upstream of the optional buffer reservoir 122.

A heat exchanger pump 153 is provided for constituting a flow of fluid between the first heat pump 110 and the heat exchanger 108 of the building 102. The heat exchanger pump 153 may be positioned upstream or downstream of the heat exchanger 108.

Any number of temperature sensors may be comprised by the thermal energy transfer system 101. A number of examples of temperature sensors are indicated in Fig. 1 and will elaborated on below. Any temperature sensor may provide a sensor signal indicative of a detected temperature, such as a fluid temperature, water temperature, and/or air temperature. The system controller may be arranged to receive sensor signals from any temperature sensor.

A primary supply temperature sensor 177 may be used to provide a sensor signal indicative of a water temperature in the primary supply conduit 142, in particular near the primary heat pump, more in particular downstream of the optional secondary return conduit 144.

A primary return temperature sensor 176 may be used to provide a sensor signal indicative of a water temperature in the primary return conduit 141, in particular near the primary heat pump. For example, when a temperature detected by the primary supply temperature sensor 177 is equal to, lower then, or within a certain narrow range of a temperature detected by the primary return temperature sensor 176, the system controller may shut down one or more pumps. The narrow range may for example be less than 1, less than 2, less than 3, or less than 5 degrees C.

One or more temperature sensors may be used to provide a sensor signal indicative of a water temperature in the sprinkler tank 104. The temperature of water in the sprinkler tank 104 may be heterogeneous, for example due to stratification. As such, multiple temperature sensors may be positioned at different fluid levels inside the sprinkler tank 104.

It may be a control objective of the system controller to keep the water temperature in the sprinkler tank 104 above a certain temperature, for example above 1 degree C, to avoid freezing of the water. Additionally, alternatively, it may be a control objective of the system controller to keep the water temperature in the sprinkler tank 104 below a certain temperature, for example below 60 degrees C, below 50 degrees C, below 40 degrees C, or even below 30 degrees C. Above a particular water temperature, undesired cavitation may occur in the water flowing to the sprinkler system 112 and/or through the thermal energy transfer system 101. In particular and for example when the thermal energy transfer system 101 is retro-fitted to an existing sprinkler system, the pump of the sprinkler system may not be arranged for operation with water with a temperature for example above 30 degrees C or above 40 degrees C without cavitation occurring.

An example of a reservoir temperature sensor 172 is depicted in Fig. 1, positioned near the sprinkler tank 104 downstream of a fluid outlet of the sprinkler tank 104.

Further depicted in Fig. 1 are a secondary supply temperature sensor 173 and a secondary return temperature sensor 174, respectively arranged for providing a sensor signal indicative of a water temperature in the secondary supply conduit 143 – in particular downstream of the buffer reservoir 122 – and for providing a sensor signal indicative of a water temperature in the secondary return conduit 144. Not depicted in Fig. 1 but as an option, a buffer temperature sensor may be used for providing a sensor signal indicative of a water temperature in the buffer reservoir 122.

A further optional bypass valve 137 is depicted in Fig. 1, and is positioned between the primary supply conduit 142 and the primary return conduit 141. In particular, the bypass valve 137 is connected to the primary supply conduit 142 downstream of the primary flow pump 151 in the embodiment of Fig. 1. As with all other valves, the bypass valve 137 may be controllable by the system controller.

In use, the thermal energy transfer arrangement 100 may be operated – for example at least partially by the system controller – in the following manner, with one or more of the optional steps disclosed herein.

A demand for thermal energy may occur in the building 102, for example when a temperature inside the building 102 is below a desired temperature. The demand for thermal energy may be at least partially fulfilled with the thermal energy transfer system 101, which may optionally be assisted with further sources of thermal energy such as one or more solar collectors, boilers working for example on gas, a central heating system, a district heating system, residual heat from industrial processes, any other preferably sustainable and/or renewable source of thermal energy, or any combination thereof.

In use, the water supply in the sprinkler reservoir 104 may be primarily intended as a water supply for the sprinkler system 112. For example in case of a fire in the building 102, water should be available to the sprinkler system 112 to attempt to put out the fire. When the thermal energy transfer system 101 is retro-fitted to an existing sprinkler system 112, it may be an aim to have essentially the same amount of water available for the sprinkler system 112 as before the retro-fit, for example within a 10%, 5% or even within a 1% range. The primary circuit 103 and the secondary circuit 107 are preferably closed-loop circuits.

The primary heat pump 110, in typical use, is used to transfer thermal energy from water from the sprinkler reservoir 104 to the heat exchanger 108 in the building 102. This causes the temperature of the water inside the sprinkler reservoir 104 to drop. Depending on ambient conditions such as the season, climate, weather, or the time of the day, a typical temperature of water in the sprinkler reservoir 104 may for example be between 8 and 15 °C.

In use, the primary heat pump 110 may for example heat the fluid in the heat exchanger circuit 105 to for example more than 40 degrees C, more than 45 degrees C, more than 50 degrees C, or even 55 degrees C or more. This temperature may be sufficient to increase the temperature in the building 102 to a desired temperature of for example more than 18, more than 20, or even more than 22 degrees C.

In order to prevent the temperature of the water in the sprinkler reservoir 104 to drop below a threshold temperature, such as for example 1 degree C, the secondary heat pump 120 is used to increase the temperature of the water in the sprinkler reservoir 104. The thermal energy required for this increase in temperature of the water may at least partially be obtained from the ambient air surrounding the secondary heat pump 120.

The particular embodiment of the thermal energy transfer system 101 depicted in Fig. 1 allows the primary heat pump 110 and the secondary heat pump 120 to simultaneously respectively withdraw and supply thermal energy from and to water from the sprinkler reservoir 104. This simultaneous operation may be achieved as follows.

During simultaneous operation, the bypass valve 137 is at least partially opened, and the primary flow pump 151 and the secondary flow pump 152 are operated to constitute a flow of water simultaneously and respectively through the primary heat pump 110 and the secondary heat pump 120.

The flow of water flowing through the primary heat pump 110 is cooled down, and re-enters the sprinkler tank 104. Part of the flow of water flowing through the primary supply conduit 142 flows through the secondary heat pump 120 and is heated up, and subsequently fed back into the sprinkler tank 104.

In the description above, it will be understood that when an element is referred to as being connect to another element, the element is either directly connected to the other element, or intervening elements may also be present. Also, it will be understood that the values given in the description above, are given by way of example and that other values may be possible and/or may be strived for.

It is to be noted that the figures are only schematic representations of embodiments that are given by way of non-limiting examples. For the purpose of clarity and a concise description, features are described herein as part of the same or separate embodiments, however, it will be appreciated that the scope of the disclosure may include embodiments having combinations of all or some of the features described.

The word ‘comprising’ does not exclude the presence of other features or steps. Furthermore, the words 'a' and 'an' shall not be construed as limited to 'only one', but instead are used to mean 'at least one', and do not exclude a plurality.

Claims

1. A thermal energy transfer arrangement (100), comprising:

- a building (102), comprising:
  - a sprinkler system (112); and
  - a heat exchanger (108) for heating the building (102);
- a sprinkler reservoir (104) arranged for holding a volume of water, wherein the sprinkler system (112) is in fluid communication with the sprinkler reservoir (104); and
- a thermal energy transfer system (101), comprising:
  - a primary heat pump (110), which is in fluid communication with the sprinkler reservoir (104) and the heat exchanger (108), and which is arranged to transfer thermal energy from the sprinkler reservoir (104) to the heat exchanger (108).

2. The thermal energy transfer arrangement (100) according to claim 1, wherein the thermal energy transfer system (101) further comprises a secondary heat pump (120), which is in fluid communication with the sprinkler reservoir (104) and the ambient surroundings of the secondary heat pump (120), wherein the secondary heat pump (120) is arranged to transfer thermal energy from a heat source such as the ambient surroundings to the sprinkler reservoir (104).

3. The thermal energy transfer arrangement (100) according to claim 2, further comprising a buffer reservoir (122) in fluid communication with the sprinkler reservoir (104) and the secondary heat pump (120), wherein the buffer reservoir (122) is positioned downstream of the sprinkler reservoir (104) and upstream of the secondary heat pump (120).

4. The thermal energy transfer arrangement (100) according to claim 2 or 3, wherein the thermal energy transfer system (101) further comprises a

primary return conduit (141) fluidly connecting the primary heat pump (110) and the sprinkler reservoir (104), and a first three-way valve (131) of which a first port is connected downstream of the sprinkler reservoir (104), a second port is connected upstream of the primary heat pump (110), and a third port is connected to the primary return conduit (141).

5. The thermal energy transfer arrangement (100) according to any of the claims 2-4, wherein the thermal energy transfer system (101) further comprises a secondary return conduit (144) fluidly connecting the secondary heat pump (120) and the sprinkler reservoir (104), and a second three-way valve (132), of which a first port is connected upstream of the secondary heat pump (120), a second port is connected to the secondary return conduit (144) downstream of the secondary heat pump (120), and a third port is connected to the sprinkler reservoir (104).

6. The thermal energy transfer arrangement (100) according to any of the preceding claims, wherein the sprinkler reservoir (104) is provided with a first fluid level sensor (121) and a second fluid level sensor (123), wherein the second fluid level sensor (123) is positioned above the first fluid level sensor (121).

7. The thermal energy transfer arrangement (100) according to any of the preceding claims, wherein the sprinkler reservoir (104) is in fluid communication with the thermal energy transfer system (101) only via one fluid outlet out of the sprinkler reservoir (104), and one fluid inlet into the sprinkler reservoir (104).

8. The thermal energy transfer arrangement (100) according to any of the preceding claims, wherein the sprinkler system (112) comprises a plurality of fire sprinklers inside the building (102).

9. A thermal energy transfer system (101) for use in a thermal energy transfer arrangement (100) comprising a sprinkler reservoir (104), in particular a thermal energy transfer arrangement (100) according to any of the claims 1-8, the thermal energy transfer system comprising:

- a primary heat pump (110);
- a primary supply conduit (142) connected to the primary heat pump (110), for receiving water from the sprinkler reservoir (104);
- a primary return conduit (141) connected to the primary heat pump (110), for returning water to the sprinkler reservoir (104);
- a secondary heat pump (120);
- a secondary supply conduit (143) connected to the secondary heat pump (120), for receiving water from the sprinkler reservoir (104);
- a secondary return conduit (144) connected to the secondary heat pump (120), for returning water to the sprinkler reservoir (104);

wherein

- the primary heat pump (110) is arranged to transfer thermal energy from a flow of water received from the primary supply conduit (142) to a heat exchanger (108) of a building; and
- the secondary heat pump (120) is arranged to transfer thermal energy from a heat source such as the ambient surroundings to water received from the secondary supply conduit (143).

10. The thermal energy transfer system (101) according to claim 9, wherein the secondary heat pump (120) is connected in parallel to the primary supply conduit (142) via the secondary supply conduit (143) and the secondary return conduit (144).

11. Method of operating a thermal energy transfer arrangement, the method comprising the steps of:

- circulating water through a primary circuit (103) formed by a sprinkler reservoir (104) and a primary heat pump (110) fluidly connected to the sprinkler reservoir (104) via a primary supply conduit (142) and a primary return conduit (141);

- operating the primary heat pump (110) to extract thermal energy from the water circulating through the primary circuit (103); and
- supplying the extracted thermal energy to a heat exchanger (108) of a building (102).

12. Method according to claim 11, further comprising the steps of:

- circulating water through a secondary circuit (107) formed by a secondary heat pump (120) fluidly connected to the sprinkler reservoir (104) via a secondary supply conduit (143) and a secondary return conduit (144); and
- operating the secondary heat pump (120) to transfer thermal energy from a thermal energy source such as ambient air to water circulating through the secondary circuit (107).

13. Method according to claim 12, wherein the primary heat pump (110) and the secondary heat pump (120) are operated simultaneously to simultaneously and respectively withdraw and supply thermal energy to the sprinkler reservoir (104).

14. Method according to any of the claims 11-13, further comprising, by a system controller, receiving a signal indicative of a water demand by a sprinkler system (112) arranged for receiving water from the sprinkler reservoir (104), and in response to the signal, reducing or stopping a flow of water from the sprinkler reservoir (104) to the primary heat pump (110).

15. Method of extracting thermal energy from water in a sprinkler reservoir, the method comprising the steps of:

- connecting a primary supply conduit (142) to the sprinkler reservoir for receiving water from the sprinkler reservoir (104);

- connecting a primary return conduit (141) to the sprinkler reservoir for returning water to the sprinkler reservoir (104);
- receiving water from the sprinkler reservoir via the primary supply conduit by a primary heat pump (110);
- extracting thermal energy from the received water by the primary heat pump (110); and
- returning water to the sprinkler reservoir (104) via the primary return conduit (141) after the extracting of thermal energy from the received water by the primary heat pump (110).

16. Method of transferring thermal energy to water in a sprinkler reservoir (104), the method comprising the steps of:
- fluidly connecting a secondary supply conduit (143) to the sprinkler reservoir for receiving water from the sprinkler reservoir (104);
- receiving water from the sprinkler reservoir (104) via the secondary supply conduit (143) by a secondary heat pump (120);
- by the secondary heat pump (120), transferring thermal energy from a heat source such as ambient air to the water received from the sprinkler reservoir; and
- returning the water from the secondary heat pump (120) to the sprinkler reservoir via a secondary return conduit (144).

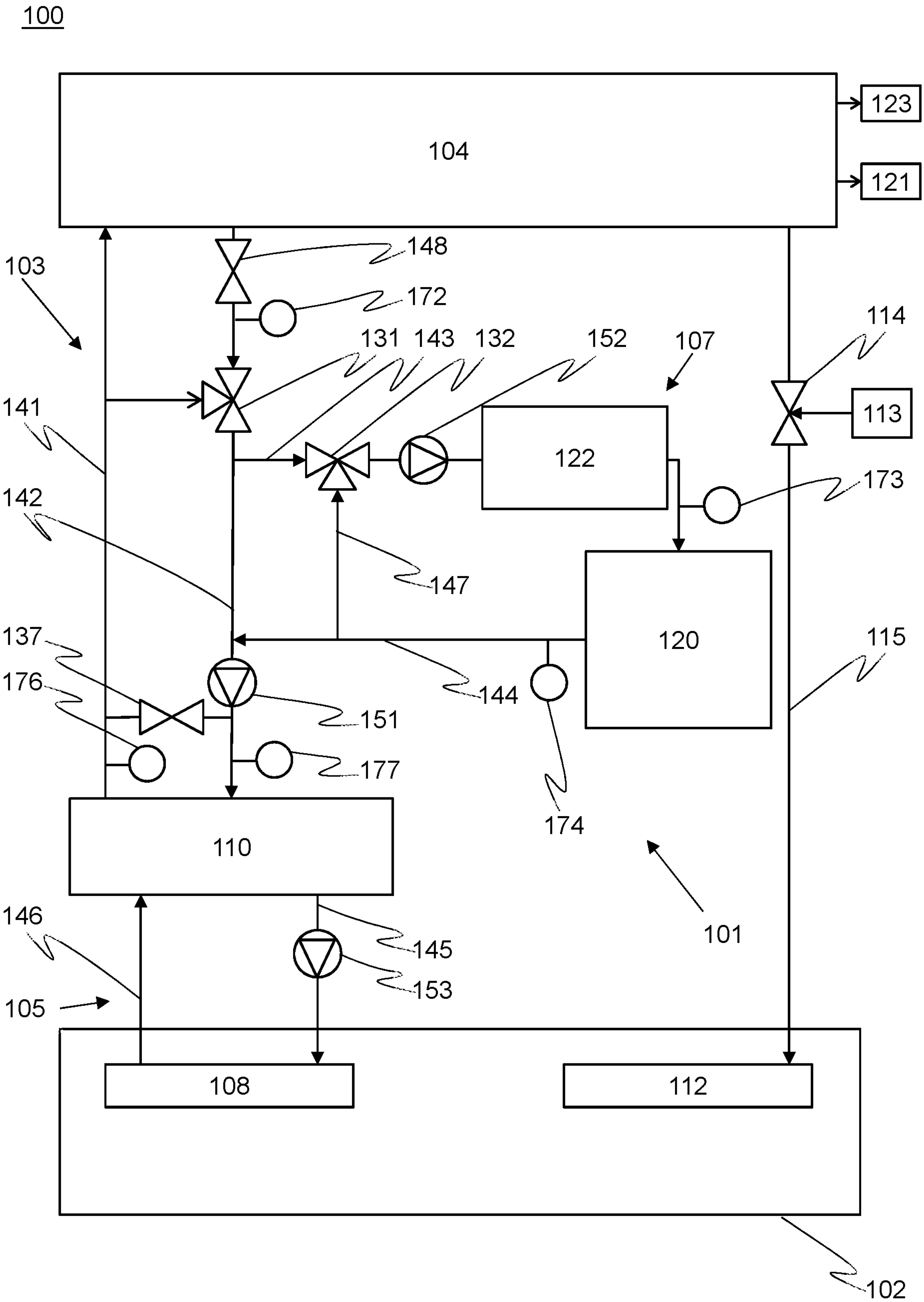
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Fig 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2023/050313

A. CLASSIFICATION OF SUBJECT MATTER
INV. F24D3/18 A62C35/60 F24D19/00 F24H15/136 F24H15/215
F24H15/219 F24H15/248 F24H15/31 F24H15/32 F24H15/325
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24D A62C F24H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 31 29 950 A1 (HOFMEISTER ARNO ING) 17 February 1983 (1983-02-17) pages 7-18; figure 1	1-16
A	DE 10 2020 110701 A1 (INNOGY SE [DE]) 21 October 2021 (2021-10-21) the whole document	1-16
A	CN 110 657 481 A (HUNAN INST ENGINEERING) 7 January 2020 (2020-01-07) the whole document	1-16
A	US 2011/259613 A1 (MORRIS DARREN JAMES [GB]) 27 October 2011 (2011-10-27) the whole document	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 2023	12/12/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schwaiger, Bernd

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2023/050313

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3129950 A1	17-02-1983	NONE	
DE 102020110701 A1	21-10-2021	NONE	
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US 2011259613 A1	27-10-2011	EP 2268367 A1	05-01-2011
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		US 2011259613 A1	27-10-2011
		WO 2009125203 A1	15-10-2009