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(54) A METHOD, FLOW CONTROL DEVICE AND COMPUTER PROGRAM PRODUCT FOR OPERATING AN HVAC SYSTEM

(57) Method of operating an HVAC system (1) comprising a thermal energy transfer device (200) fluidically connected to a thermal energy source (100) by a primary fluid circuit (400) and further fluidically connected to thermal energy consumer(s) (300) by a secondary fluid circuit (500), the method comprising determining a flow rate (Φ) of a fluid in the primary fluid circuit (400); determining a temperature of a fluid in the secondary fluid circuit (500); and controlling, by a flow control device (10) arranged in the primary fluid circuit (400), the flow rate (Φ) of the fluid in the primary fluid circuit (400) using the temperature of the fluid in the secondary fluid circuit (500).

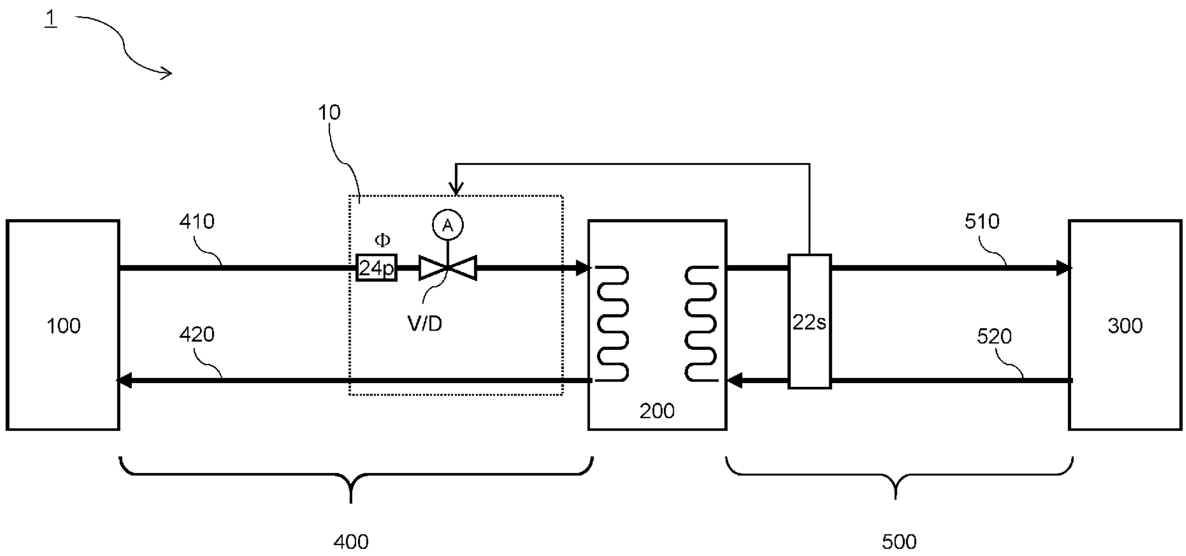

Fig. 1

Processed by Luminess, 75001 PARIS (FR)

Description

Field of the invention

[0001] The present invention relates to a method of operating an HVAC system comprising a thermal energy transfer device fluidically connected to a thermal energy source by a primary fluid circuit and further fluidically connected to thermal energy consumer(s) by a secondary fluid circuit. The present invention further relates to a flow control device for being arranged in a primary fluid circuit of an HVAC system comprising a thermal energy transfer device fluidically connected to a thermal energy source by a primary fluid circuit and further fluidically connected to thermal energy consumer(s) by a secondary fluid circuit. The present invention further relates to an HVAC system comprising a thermal energy transfer device fluidically connected to a thermal energy source by a primary fluid circuit and further fluidically connected to thermal energy consumer(s) by a secondary fluid circuit. The present invention even further relates to a computer program product for operating an HVAC system.

Background of the invention

[0002] As people spend an estimated 90% of their time indoors, Heating, Ventilating and Air Conditioning HVAC systems have become of great importance to everyday life and have a great impact on people's health and comfort.

[0003] Various thermal networks are known for enabling transfer of thermal energy from a (potentially shared) thermal energy source to one or more controlled environment(s), such as district heating, district cooling and low temperature networks. Alternatively, or additionally, thermal networks are known for enabling transfer of thermal energy from one or more controlled environment(s), whereby the controlled environment(s) act as an energy source, for example by capturing thermal energy as a by-product of an industrial process.

[0004] In thermal networks of the district heating or cooling type and of the low temperature network type, a thermal energy source is fluidically connected by a primary fluid circuit to a primary side of a thermal energy transfer device, thermal energy consumer(s) being fluidically connected by a secondary fluid circuit to a secondary side of the thermal energy transfer device.

[0005] In thermal networks of the district heating type, the fluid circulating in the primary fluid circuit is typically characterized by high supply temperatures (e.g. between 60 and 130°C) from the thermal energy source, a thermal energy transfer device, such as a heat exchanger being arranged to decouple the district heating network from the thermal energy consumer (located or thermally coupled with the controlled environment).

[0006] In thermal networks of the district cooling type, the fluid circulating in the primary fluid circuit is typically characterized by very low supply temperatures (e.g. between -1 and 7°C) from the thermal energy source, a thermal energy transfer device, such as a heat exchanger being arranged to decouple the district cooling network from the thermal energy consumer (located or thermally coupled with the controlled environment).

[0007] In thermal networks of the low temperature network type, also referred to as 5th generation district heating, the fluid circulating in the primary fluid circuit is typically characterized by moderate supply temperatures (e.g. between 2 and 20°C) from the thermal energy source, a thermal energy transfer device, such as a heat pump being arranged to decouple the low temperature network from the thermal energy consumer (located or thermally coupled with the controlled environment). Furthermore, the thermal energy transfer device, such as a heat pump, is arranged to supplement the thermal energy provided by the thermal energy source, transferring the moderate temperature of the network to a higher or a lower temperature which can be used for heating, respectively cooling. Low temperature networks often incorporate sustainable energy sources (e.g. ground heat) and can be used for both heating and cooling of buildings. In such networks, heat pumps are often used for space heating and domestic hot water, whereas in some cases cooling can be supplied directly using heat exchangers only.

[0008] However, it has been observed that known methods/ systems for operating HVAC systems comprising a thermal energy source and a thermal energy transfer device often operate sub-optimally, unreliably and/or are prone to failures.

Summary of the invention

[0009] It is an object of embodiments disclosed herein to at least partially overcome the disadvantages of known methods/ systems for operating HVAC systems comprising a thermal energy transfer device fluidically connected to a thermal energy source by a primary fluid circuit and further fluidically connected to thermal energy consumer(s) by a secondary fluid circuit.

[0010] Applicant has identified that known methods/ systems (for operating HVAC systems comprising a thermal energy source connected to a thermal energy transfer device by a primary fluid circuit, thermal energy consumer(s) being connected to thermal energy transfer device by a secondary fluid circuit) often operate sub-optimally due to the fact that known methods/ systems do not consider conditions within the secondary fluid circuit when controlling parameters of the primary fluid circuit.

[0011] Therefore, it is an object of embodiments disclosed herein to provide a method of operating HVAC systems (comprising a thermal energy source connected to a thermal energy transfer device by a primary fluid circuit, thermal energy consumer(s) being connected to thermal energy transfer device by a secondary fluid circuit) which take into account conditions within the secondary fluid circuit when controlling parameters of the primary fluid circuit.

[0012] According to the present disclosure, this object is achieved by the features of the independent claim 1. In addition, further advantageous embodiments follow from the dependent claims and the description.

[0013] In particular, the above-identified objectives are addressed according to the present disclosure by a method of operating an HVAC system comprising a thermal energy transfer device fluidically connected to a thermal energy source by a primary fluid circuit and further fluidically connected to thermal energy consumer(s) by a secondary fluid circuit, the method comprising: determining a flow rate of a fluid in the primary fluid circuit; determining a temperature of a fluid in the secondary fluid circuit; and controlling the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit by a flow control device arranged in the primary fluid circuit.

[0014] According to embodiments disclosed herein, the fluid is a gaseous fluid, such as air and/or a liquid, such as water. The term thermal energy source is used in the context of the present invention to refer to a source of both heating and cooling energy source. Correspondingly, according to embodiments of the HVAC system, the thermal energy source is configured to supply heat to the thermal energy transfer device - referred to as heating. Alternatively, or additionally the thermal energy source is configured to extract heat from the thermal energy transfer device - referred to as cooling.

[0015] According to particular embodiments of the present disclosure, the thermal energy source is part of a thermal network such as a district heating/ cooling or low temperature network, while the thermal energy transfer device is a heat exchanger. Alternatively or additionally, the thermal energy transfer device comprises a heat pump configured to supplement the thermal energy provided by the thermal energy source.

[0016] In a first step of the method, a flow rate of the fluid in the primary fluid circuit is determined (continuously, pseudo-continuously and/or at intervals during operation of the HVAC system), in particular using a flow rate sensor device configured, respectively arranged to determine the flow rate of the fluid in a primary fluid circuit.

[0017] In addition, a temperature of a fluid in the secondary fluid circuit is determined, such as a supply temperature and/or a return temperature measured in a supply fluid transportation line respectively in a return fluid transportation line of the secondary fluid circuit, in particular using a temperature sensor device configured, respectively arranged to determine a temperature of a fluid in a secondary fluid circuit. Having determined the flow rate of the fluid in the primary fluid circuit and the temperature of a fluid in the secondary fluid circuit, the flow rate of the fluid in the primary fluid circuit is controlled as a function of the temperature of the fluid in the secondary fluid circuit. The flow rate of the fluid in the primary fluid circuit is controlled using a flow control device arranged in the primary fluid circuit. According to embodiments disclosed herein, the flow control device comprises a valve and/or a damper drivingly connected to an actuator configured to control a flow rate of the fluid in the primary fluid circuit, e.g. by varying dimensions of an orifice through which the fluid flows. Alternatively, or additionally, the flow rate of the fluid in the primary fluid circuit is controlled by controlling the power of a fluid conveying device, such as a pump or fan.

[0018] In applications of district heating/ cooling or low temperature network, it is a common requirement to provide the district energy provider the means to limit the rate and/or amount of thermal energy delivered to consumers. By limiting the rate and/or amount of thermal energy delivered to consumers, the district energy provider can balance the load between consumers and/or ensure that each consumer is provided with a set minimum rate and/or amount of thermal energy, e.g. to comply with a service level agreement. Therefore, it is an objective of further embodiments to enable a control over a rate and/or amount of thermal energy drawn by the thermal energy transfer device from the thermal energy source.

[0019] According to embodiments of the present disclosure, the supply temperature and the return temperature of the fluid in the primary fluid circuit are measured, in particular in a supply fluid transportation line and/or a return fluid transportation line connecting the thermal energy source and the thermal energy transfer device. In particular, the supply temperature and the return temperature of the fluid in the primary fluid circuit are measured using a further temperature sensor device configured, respectively arranged to determine the supply temperature of the fluid and the return temperature of the fluid in the primary fluid circuit. Alternatively, or additionally, the supply temperature is determined based on a measurement of the return temperature and data indicative of the relationship between the supply temperature and the return temperature using the flow rate. Alternatively, or additionally, the return temperature is determined based on a measurement of the supply temperature and data indicative of the relationship between the supply temperature and the return temperature using the flow rate.

[0020] Based on the determined supply temperature, return temperature and flow rate of the fluid in the primary fluid circuit, a rate of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit is determined. Correspondingly, the flow rate of the fluid in the primary fluid circuit is controlled further to ensuring that the rate of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit does not exceed an energy transfer threshold. Alternatively, or additionally, an amount of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit is determined - during a given time period based on the determined supply temperature, return temperature and flow rate of the fluid in the primary fluid circuit. Correspondingly, the flow rate of the fluid in the primary fluid circuit is controlled further to ensuring that the amount of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit does not exceed an energy transfer threshold.

[0021] According to embodiments, the rate of thermal energy transfer and/or the amount of thermal energy transfer are determined by a metering unit of the flow control device. In order to ensure reliable, certifiable respectively unfalsifiable measurements of the rate of thermal energy transfer and/or the amount of thermal energy transfer, the metering unit is a logically, electrically and/or physically isolated subsystem within the flow control device. According to an embodiment, the metering unit is implemented as a subsystem within the processing unit, e.g. as a co-processor. Alternatively, or additionally to a logical and/or electrical isolation, in order to prevent manipulation, the metering unit is provided with a seal.

[0022] In order to ensure continuous recording of the rate of thermal energy transfer and/or the amount of thermal energy transfer, according to embodiments, the metering unit is provided with a redundant and/or supplementary power supply, such as a battery and/or a capacitor.

[0023] To allow a read-out of the rate of thermal energy transfer and/or the amount of thermal energy transfer directly from the flow control device, according to embodiments, the flow control device comprises a display, configured to display an indication of the rate of thermal energy transfer and/or the amount of thermal energy transfer, continuously, at set intervals and/or upon request, such as by a push button.

[0024] According to embodiments, the flow rate of the fluid in the primary fluid circuit is controlled further ensuring that the return temperature is above a minimum return temperature threshold. Ensuring that the return temperature is above a minimum return temperature threshold avoids the thermal energy transfer device and/or the primary fluid circuit from being damaged due to freezing and/or condensation of the fluid.

[0025] Alternatively, or additionally the flow rate of the fluid in the primary fluid circuit is controlled further ensuring that the return temperature is below a maximum return temperature threshold. Ensuring that the return temperature is below a maximum return temperature threshold....

[0026] According to further embodiments, the flow rate of the fluid in the primary fluid circuit is controlled ensuring that the return temperature is above a minimum return temperature threshold or below a maximum return temperature threshold in accordance with a set operating mode, such as a cooling or heating operating mode.

[0027] According to embodiments, determining the temperature of the fluid in the secondary fluid circuit comprises determining a supply temperature (e.g. measured in a supply fluid transportation line) and a return temperature (e.g. measured within a return fluid transportation line of the secondary fluid circuit). In orderto more optimally operate the HVAC system, the flow rate of the fluid in the primary fluid circuit is controlled further to maintain a target temperature differential between the supply temperature and the return temperature in the secondary fluid circuit.

[0028] According to embodiments of the present disclosure, controlling the flow rate of the fluid such as to maintain a target temperature differential in the secondary fluid circuit comprises:

- Maintaining a target temperature differential as a function of the supply temperature, advantageous as it enables accounting for different levels of supply temperatures. Compared to a fixed temperature differential, a target temperature differential as a function of the supply temperature enables increased efficiency and ensures the system is also optimized in partial load.

- Maximizing the temperature differential, advantageous in particular in HVAC systems wherein minimizing the flow of the fluid is desired, e.g. when the fluid needs to be conveyed over long distances/ great differences in elevation and/or in case billing of energy costs is based on volume of supplied fluid.

- Maintain a predefined return temperature range in the secondary fluid circuit, advantageous in particular in HVAC systems where the return temperature should not exceed a set threshold.

[0029] According to embodiments, the flow rate of the fluid in the primary fluid circuit is controlled further ensuring that the flow rate is above an operational flow rate threshold of the thermal energy transfer device. Adherence to this criterion addresses the aim to ensure that the HVAC system operates optimally, with fewer interruptions and less prone to errors. Ensuring that the flow rate is above an operational flow rate threshold of the thermal energy transfer device helps avoid unnecessary interruptions in the operation of the HVAC system due to the thermal energy transfer device being forced to shut down due to insufficient flow rate. Furthermore, ensuring that the flow rate is above an operational flow rate threshold of the thermal energy transfer device prevents unnecessary wear of the thermal energy transfer device due to operation near or below optimum parameters.

[0030] According to embodiments of the present disclosure, the flow rate of the fluid in the primary fluid circuit is controlled further such as to ensure that a temperature differential - between the supply temperature and the return temperature of the fluid in the primary fluid circuit - does not fall below a minimum temperature differential and/or does not exceed a maximum temperature differential. This allows an operator of the thermal energy source to set limits of the temperature differential between the supplied and returned fluid. For example, setting of a minimum temperature differential is advantageous in particular in HVAC systems wherein minimizing the flow of the fluid is desired, e.g. when the fluid needs to be conveyed over long distances/ great differences in elevation and/or in case billing of energy costs is based on volume of supplied fluid. On the other hand, setting a maximum temperature differential is advantageous in balancing the amount of thermal energy transferred (in relation to the fluid flow) to/from multiple energy consumers connected to the same thermal energy source. For example, setting a maximum temperature differential between the supply and return temperatures in the primary fluid circuit ensures that sufficient thermal energy remains available for other downstream thermal energy transfer devices.

[0031] According to further embodiments of the present disclosure, the flow control device is communicatively connected to the thermal energy transfer device to receive a signal indicative of a thermal energy demand thereof. In order to operate the HVAC system even more efficiently, the flow rate of the fluid in the primary fluid circuit is controlled further as a function of the thermal energy demand. In particular, increasing the flow rate at predetermined time interval(s), in the presence of thermal energy demand - while maintaining the target temperature differential and ensuring that the return temperature is above a minimum return temperature threshold. Hence, if the flow rate has been previously reduced or if the flow control device has been previously closed off, the flow control device makes successive attempts to meet the energy demand (in the presence of an energy demand)-while meeting the safe conditions of minimum return temperature threshold and operational flow rate threshold. According to further embodiments, a time interval between successive attempts to meet the energy demand (by increasing the flow-rate) is gradually increased after each attempt, the time interval being reset to an initial value after a successful attempt.

[0032] It is a further object of the present disclosure to provide a flow control device for controlling an HVAC system (comprising a thermal energy source connected to a thermal energy transfer device by a primary fluid circuit, thermal energy consumer(s) being connected to thermal energy transfer device by a secondary fluid circuit) which take into account conditions within the secondary fluid circuit when controlling parameters of the primary fluid circuit.

[0033] According to the present disclosure, this object is achieved by the features of the independent claim 8. In addition, further advantageous embodiments follow from the dependent claims and the description.

[0034] In particular, the above-identified objectives are addressed according to the present disclosure by a flow control device comprising: a valve and/or a damper drivingly connected to an actuator and/or an interface communicatively connectable to a pump and/or a fan; a flow rate sensor device and/or an interface for receiving sensor data from a flow rate sensor device; a temperature sensor device and/or an interface for receiving sensor data from a temperature sensor device; and a processing unit. The valve and/or damper are drivingly connected to an actuator configured to control a flow rate of a fluid in a primary fluid circuit of the HVAC system, e.g. by varying dimensions of an orifice through which the fluid flows. The flow rate sensor device is configured, respectively arranged to determine the flow rate of the fluid in a primary fluid circuit. The temperature sensor device is configured, respectively arranged to determine a temperature of a fluid in a secondary fluid circuit, such as a supply temperature and/or a return temperature of the secondary fluid circuit 500 connecting the thermal energy consumer. In particular, the temperature sensor device comprises a first temperature sensor configured, respectively arranged to determine a supply temperature in a supply fluid transportation line of the secondary fluid circuit and a second temperature sensor configured, respectively arranged to determine a return temperature in a return fluid transportation line of the secondary fluid circuit.

[0035] The processing unit is communicatively connected to the actuator and configured to control the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit, in particular by generating control signals causing the actuator to drive the valve and/or damper. Alternatively, or additionally, the processing unit is communicatively connectable, via an interface, to a pump and/or a fan and configured to control the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit, in particular by generating control signals varying the power of the pump and/or fan.

[0036] In order to enable determining a rate and/or amount of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit, according to embodiments of the present disclosure, the flow control device further comprises a further temperature sensor device configured, respectively arranged to determine the supply temperature of the fluid and the return temperature of the fluid in the primary fluid circuit. In particular, the further temperature sensor device comprises a first temperature sensor configured to determine the supply temperature of the fluid to the thermal energy source and a second temperature sensor configured to determine the return temperature of the fluid from the thermal energy source. Alternatively, or additionally, the flow control device comprises an interface for receiving sensor data from a further temperature sensor device configured, respectively arranged to determine the supply temperature of the fluid and the return temperature of the fluid in the primary fluid circuit. Furthermore, the processing unit is configured to determine a rate and/or amount of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit based on the supply temperature, the return temperature and the flow rate of the fluid in the primary fluid circuit. In order to enable a control over a rate and/or amount of thermal energy drawn by the thermal energy transfer device from the thermal energy source, the processing unit is configured to control the flow rate of the fluid in the primary fluid circuit further to ensure that the rate and/or amount of thermal energy transfer between the primary fluid circuit and the secondary fluid circuit does not exceed an energy transfer threshold.

[0037] According to embodiments, the rate of thermal energy transfer and/or the amount of thermal energy transfer are determined by a metering unit of the flow control device. In order to ensure reliable, certifiable respectively unfalsifiable measurements of the rate of thermal energy transfer and/or the amount of thermal energy transfer, the metering unit is a logically, electrically and/or physically isolated subsystem within the flow control device. According to an embodiment, the metering unit is implemented as a subsystem within the processing unit, e.g. as a co-processor. Alternatively, or additionally to a logical and/or electrical isolation, in order to prevent manipulation, the metering unit is provided with a seal. In order to ensure continuous recording of the rate of thermal energy transfer and/or the amount of thermal energy transfer, according to embodiments, the metering unit is provided with a redundant and/or supplementary power supply, such as a battery and/or a capacitor. To allow a read-out of the rate of thermal energy transfer and/or the amount of thermal energy transfer directly from the flow control device, according to embodiments, the flow control device comprises a display, configured to display an indication of the rate of thermal energy transfer and/or the amount of thermal energy transfer, continuously, at set intervals and/or upon request, such as by a push button.

[0038] According to further embodiments disclosed herein, the flow control device further comprises a further flow rate sensor device configured, respectively arranged to determine a flow rate of the fluid in the secondary fluid circuit. Alternatively, or additionally, the flow control device comprises an interface for receiving sensor data from a further flow rate sensor device configured, respectively arranged to determine a flow rate of the fluid in the secondary fluid circuit. The processing unit is further configured to determine a thermal energy demand of the thermal energy consumer based on the flow rate in the secondary fluid circuit. Alternatively, or additionally, the flow control device further comprises a communication interface configured to receive a signal indicative of a thermal energy demand of the thermal energy consumer. In order to operate the HVAC system even more efficiently, the processing unit is configured to control the flow rate of the fluid in the primary fluid circuit further using the thermal energy demand. For example, the processing unit is configured to increase the primary flow rate at predetermined time interval(s), in the presence of thermal energy demand.

[0039] According to embodiments, the flow control device further comprises a communication interface configured to receive a signal indicative of a thermal energy demand of the thermal energy consumer. In order to operate the HVAC system even more efficiently, the processing unit is further configured to control the flow rate of the fluid in the primary fluid circuit further as a function of the thermal energy demand. In particular, increasing the flow rate at predetermined time interval(s), in the presence of thermal energy demand - while maintaining the target temperature differential and ensuring that the return temperature is above a minimum return temperature threshold. Hence, if the flow rate has been previously reduced or if the flow control device has been previously closed off, the flow control device makes successive attempts to meet the energy demand (in the presence of an energy demand)- while meeting the safe conditions of minimum return temperature threshold and operational flow rate threshold. According to further embodiments, a time interval between successive attempts to meet the energy demand (by increasing the flow-rate) is gradually increased after each attempt, the time interval being reset to an initial value after a successful attempt.

[0040] In order to enable an HVAC system to be controlled - at least partially remotely/ centrally - the flow control device further comprising a communication interface configured to receive, from a remote computer, control signals for controlling the flow rate of the fluid in the primary fluid circuit. According to embodiments, the remote computer comprises one or more of: a physical or virtual server; a cloud-based computing environment; and/or a mobile device, such as a tablet computer, a mobile phone or a dedicated mobile computing device, provided with an application for operating an HVAC system such as a Building Automation or Building Management System BMS.

[0041] According to embodiments, the communication interface of the flow control device comprises a radio communication circuit, in particular a Wireless Local Area Network WLAN communication circuit; a Near Field Communication NFC, Ultra Wide Band UWB and/or a Bluetooth Low Energy BLE. According to further embodiments, the communication interface of the flow control device 10 comprises a wired communication circuit, in particular an Ethernet communication circuit a BACnet, a ModBus and/or an MP-Bus communication circuit.

[0042] It is a further object of the present disclosure to provide an HVAC system that can be controlled taking into account conditions within the secondary fluid circuit when controlling parameters of the primary fluid circuit.

[0043] According to the present disclosure, this object is achieved by the features of the independent claim 13. In addition, further advantageous embodiments follow from the dependent claims and the description.

[0044] In particular, the above object is addressed by an HVAC system comprising a thermal energy source, a thermal energy transfer device, a primary fluid circuit, a thermal energy consumer fluidically connected with the thermal energy transfer device by a secondary fluid circuit, and a flow control device according to one of the embodiments disclosed herein, arranged to control a flow rate of the fluid in the primary fluid circuit, the HVAC system being configured to carry out the method of operating an HVAC system according to one of the embodiments disclosed herein. The primary fluid circuit comprises a supply fluid transportation line arranged to transport a fluid from the thermal energy source to the thermal energy transfer device and a return fluid transportation line arranged to transport the fluid from the thermal energy transfer device to the thermal energy source. The secondary fluid circuit comprises a supply fluid transportation line arranged to transport a fluid from the thermal energy transfer device to the thermal energy consumer; and a return fluid transportation line arranged to transport the fluid from the thermal energy consumer to the thermal energy transfer device.

[0045] According to embodiments, in order to enable an HVAC system to be controlled - at least partially remotely/ centrally, the HVAC system further comprises a remote computer communicatively connected with the flow control device, the remote computer being configured to transmit control signals for controlling the flow rate of the fluid in the primary fluid circuit to the flow control device.

[0046] It is a further object of the present disclosure to provide a computer program product, comprising instructions, which - when executed by a processing unit of a flow control device enable the operation of an HVAC system taking into account conditions within the secondary fluid circuit when controlling parameters of the primary fluid circuit.

[0047] According to the present disclosure, this object is achieved by the features of the independent claim 15. In addition, further advantageous embodiments follow from the dependent claims and the description.

[0048] In particular, this object is addressed by a computer program product comprising instructions which, when executed by a processing unit of a flow control device, cause the flow control device to carry out the method according to one of the embodiments disclosed herein.

[0049] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

Brief Description of the Drawings

[0050] The herein described disclosure will be more fully understood from the detailed description given herein below and the accompanying drawings which should not be considered limiting to the disclosure described in the appended claims. The drawings which show:

Figure 1: a highly schematic block diagram of an embodiment of the HVAC system according to the present disclosure;

Figure 2: a highly schematic block diagram of an embodiment of the flow control device according to the present disclosure;

Figure 3: a highly schematic block diagram of a further embodiment of the HVAC system according to the present disclosure;

Figure 4: a flowchart illustrating steps of an embodiment of the method of operating an HVAC system according to the present disclosure;

Figure 5: a flowchart illustrating steps of a further embodiment of the method of operating an HVAC system according to the present disclosure, enabling limiting the rate and/or amount of thermal energy delivered to consumers;

Figure 6: a flowchart illustrating cumulative or alternative steps of further embodiments of the method of operating an HVAC system according to the present disclosure.

Detailed Description

[0051] Reference will now be made in detail to certain embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all features are shown. Indeed, embodiments disclosed herein may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0052] Figure 1 shows a highly schematic block diagram of an embodiment of the HVAC system 1 according to the present disclosure, comprising a thermal energy source 100 and a thermal energy transfer device 200 connected by a primary fluid circuit 400. The primary fluid circuit 400 comprises a supply fluid transportation line 410 arranged to transport a fluid from the thermal energy source 100 to the thermal energy transfer device 200 and a return fluid transportation line 420 arranged to transport the fluid from the thermal energy transfer device 200 to the thermal energy source 100.

[0053] The thermal energy source 100 is configured to supply heating and cooling energy to the thermal energy transfer device 200 such as to supply/ extract heat to/from the thermal energy transfer device 200. The thermal energy (heating / cooling) is supplied/ extracted by means of the fluid flowing through the primary fluid circuit 400.

[0054] The HVAC system 1 further comprises a secondary fluid circuit 500, fluidically connecting the thermal energy transfer device 200 with an energy consumer 300. The secondary fluid circuit 500 comprises a supply fluid transportation line 510 and a return fluid transportation line 520 for transporting a fluid between the thermal energy transfer device 200 and the thermal energy consumer 300.

[0055] In order to transfer thermal energy (heating / cooling) between the primary fluid circuit 400 and the secondary fluid circuit 500, the thermal energy transfer device 200 comprises a heat exchanger, connected to both the primary fluid circuit 400 and the secondary fluid circuit 500 such as to enable thermal transfer there-between.

[0056] Additionally or alternatively, the thermal energy transfer device 200 comprises a secondary thermal energy source such as a heat pump, a combustion heater, an electric heater or chiller or a combination thereof, configured to supplement the thermal energy provided by the thermal energy source 100.

[0057] As illustrated, the HVAC system 1 further comprises a flow control device 10 to control the flow rate Φ of the fluid in the primary fluid circuit 400. Details of the flow control device 10 are described below with reference to figure 2.

[0058] Figure 2 shows a highly schematic block diagram of an embodiment of the flow control device 10 according to the present disclosure. The flow control device 10 comprises a valve V and/or a damper D drivingly connected to an actuator A and/or an interface communicatively connectable to a pump P and/or a fan F, a flow rate sensor device 24p and/or an interface for receiving sensor data from a flow rate sensor device 24p, a temperature sensor device 22s and/or an interface for receiving sensor data from a temperature sensor device 22s, and a processing unit 20. The valve Vand/or damper Dare drivingly connected to an actuator A configured to control a flow rate Φ of a fluid in a primary fluid circuit 400 of the HVAC system 1, e.g. by varying dimensions of an orifice through which the fluid flows. The flow rate sensor device 24p is configured, respectively arranged to determine the flow rate Φ of the fluid in a primary fluid circuit 400. The temperature sensor device 22s is configured, respectively arranged to determine a temperature of a fluid in a secondary fluid circuit 500, such as a supply temperature and/or a return temperature of the secondary fluid circuit connecting the thermal energy consumer.

[0059] The processing unit 20 is communicatively connected to the actuator A and configured to control the flow rate Φ of the fluid in the primary fluid circuit 400 using the temperature of the fluid in the secondary fluid circuit 500, in particular by generating control signals causing the actuator A to drive the valve V and/or damper D.

[0060] Optionally, shown on the figures with dashed lines, in order to enable determining a rate P and/or amount of thermal energy transfer E between the primary fluid circuit 400 and the secondary fluid circuit 500, the flow control device 10 further comprises a further temperature sensor device 22p configured, respectively arranged to determine the supply temperature Ts of the fluid and the return temperature Tr of the fluid in the primary fluid circuit 400. In particular, the further temperature sensor device 22p comprises a first temperature sensor S1p configured to determine the supply temperature Ts of the fluid to the thermal energy source 100 and a second temperature sensor S2p configured to determine the return temperature Tr of the fluid from the thermal energy source 100. Alternatively, or additionally, the flow control device 10 comprises an interface for receiving sensor data from a further temperature sensor device 22p configured, respectively arranged to determine the supply temperature Ts of the fluid and the return temperature Tr of the fluid in the primary fluid circuit 400. Furthermore, the processing unit 20 is configured to determine a rate P and/or amount of thermal energy transfer E between the primary fluid circuit 400 and the secondary fluid circuit 500 based on the supply temperature Ts, the return temperature Tr and the flow rate Φ of the fluid in the primary fluid circuit 400. In order to enable a control over a rate and/or amount of thermal energy drawn by the thermal energy transfer device 200 from the thermal energy source 100, the processing unit 20 is configured to control the flow rate Φ of the fluid in the primary fluid circuit 400 further to ensure that the rate P and/or amount of thermal energy transfer E between the primary fluid circuit 400 and the secondary fluid circuit 500 does not exceed an energy transfer threshold P_{max}, Emax.

[0061] Optionally - shown on the figures with dashed lines - the flow control device 10 comprises a metering unit 30 for determining the rate P of thermal energy transfer and/or the amount of thermal energy transfer E. In order to ensure reliable, certifiable respectively unfalsifiable measurements of the rate P of thermal energy transfer and/or the amount of thermal energy transfer E, the metering unit 30 is a logically, electrically and/or physically isolated subsystem within the flow control device 10. According to an embodiment, the metering unit 30 is implemented as a subsystem within the processing unit 20, e.g. as a co-processor. Alternatively, or additionally to a logical and/or electrical isolation, in order to prevent manipulation, the metering unit 30 is provided with a seal. In order to ensure continuous recording of the rate P of thermal energy transfer and/or the amount of thermal energy transfer E, according to embodiments, the metering unit 30 is provided with a redundant and/or supplementary power supply 32, such as a battery and/or a capacitor. To allow a read-out of the rate P of thermal energy transfer and/or the amount of thermal energy transfer E directly from the flow control device 10, according to embodiments, the flow control device 10 comprises a display 34, configured to display an indication of the rate P of thermal energy transfer and/or the amount of thermal energy transfer E, continuously, at set intervals and/or upon request, such as by a push button.

[0062] Optionally, the flow control device 10 further comprises a data store 27 for storing data content comprising configuration data of the flow control device 10, and for operation-related data recorded by the flow control device 10.

[0063] The flow control device 10, in particular its processing unit 20, actuator A, and sensor device(s) 22p, is powered by a power supply comprising a power connector and/or an internal energy storage device, such as battery and/or a capacitor. According to particular embodiments, the power connector is connected to the wired communication circuit, the flow control device 10 being powered by a data line connection, such as Power over Ethernet PoE or Power over Data Line PoDL.

[0064] The flow control device 10 comprises a flow rate sensor device 24p configured, respectively arranged to determine the flow rate Φ of the fluid in a primary fluid circuit 400.

[0065] The flow control device 10 further comprises a processing unit 20. Depending on the embodiment, the processing unit 20 comprises an electronic circuit implemented as programmed processors, including data and program memory, or another programmable logic unit, e.g. an application specific integrated circuit ASIC.

[0066] Optionally, shown on the figures with dashed lines, the flow control device 10further comprises a further flow rate sensor device 24s configured, respectively arranged to determine a flow rate Φ2 of the fluid in the secondary fluid circuit 500.

[0067] Optionally, the flow control device 10 further comprises a communication interface 26 configured for data communication with a remote computer 1000 to receive control signals for controlling the flow rate Φ of the fluid in the primary fluid circuit 400

[0068] According to embodiments, the remote computer 1000 comprises one or more of:

- a physical or virtual server;
- a cloud-based computing environment; and/or
- a mobile device, such as a tablet computer, a mobile phone or a dedicated mobile computing device

provided with an application for operating an HVAC system such as a Building Automation or Building Management System BMS.

[0069] According to embodiments, the communication interface 26 comprises one or more of:

- A wired communication interface (such as an Ethernet, in particular a Power over Ethernet PoE, Single Pair Ethernet SPE, a BUS, in particular an MP Bus, BACnet, KNX or Modbus interface);
- A Wide Area Network communication circuit (such as GSM, LTE, 3G, 4G or 5G mobile communications circuit);
- A Low Power Wide Area Network (such as Narrowband Internet of Things NB-IoT, Long Range LoRa/ LoRaWAN, SigFox, or Long Term Evolution Category M1 LTE-CatM1);
- A local area network communication circuit (such as Wireless LAN);
- A short range wireless communication circuit (such as Bluetooth, Bluetooth low energy BLE, Ultra-wideband UWB, Thread and/or Zigbee); and/ or
- A close-range wireless communication circuit (such as Radio Frequency Identification RFID or a Near Field Communication NFC).

[0070] In order to accommodate HVAC systems where one or more of the sensor devices are not integrated into the flow control device 10, the communication interface 26 is configured to receive sensor data from a communicatively connected flow rate sensor device 24p, further flow rate sensor device 24s, temperature sensor device 22s, and/or further temperature sensor device 22p.

[0071] Figure 3 shows a highly schematic block diagram of further embodiment of the HVAC system 1 according to the present disclosure. Alternatively, or additionally to controlling the flow rate Φ of the fluid in the primary fluid circuit 400 by causing the actuator A to drive the valve V and/or damper D, a pump/fan 450 may be provided to induce the flow of fluid through the primary fluid circuit 400. Correspondingly, the processing unit 20 is communicatively connectable, via an interface, to the pump P and/or fan F and configured to control the flow rate Φ of the fluid in the primary fluid circuit 400 by generating control signals varying the power of the pump P and/or fan F.

[0072] As also shown on figure 3, the temperature sensor device 22s comprises a first temperature sensor S1s configured, respectively arranged to determine a supply temperature T2s in a supply fluid transportation 510 line of the secondary fluid circuit 500 and a second temperature sensor S2s configured, respectively arranged to determine a return temperature T2r in a return fluid transportation 520 line of the secondary fluid circuit 500.

[0073] As also shown on figure 3, the further temperature sensor device 22p comprises a first temperature sensor S1p configured to determine the supply temperature Ts of the fluid to the thermal energy source 100 and a second temperature sensor S2pconfigured to determine the return temperature Tr of the fluid from the thermal energy source 100.

[0074] As further illustrated on figure 3, a remote computer 1000 may be communicatively connected to the flow control device 10, to receive control signals for controlling the flow rate Φ of the fluid in the primary fluid circuit 400.

[0075] As shown with dashed lines on figure 3, according to embodiments, the flow control device 10 is communicatively connected with the further flow rate sensor device 24s and/or the temperature sensor device 22s via a further control unit 530. For example, the control unit 530 may be configured to generate a control signal, such as an analog or digital signal, based on measurement signal(s) of the further flow rate sensor device 24s and/or the temperature sensor device 22s. Alternatively, or additionally, the flow control device 10 is communicatively connected with the further flow rate sensor device 24s and/or the temperature sensor device 22s via the remote computer 1000.

[0076] Turning now to figures 4 to 7, embodiments of the method of operating the HVAC system 1 shall be described in detail.

[0077] Figure 4 depicts a flowchart illustrating steps of an embodiment of the method of operating an HVAC system 1 according to the present disclosure. In a first, preparatory step 510, a flow control device 10 is arranged between the thermal energy source 100and the thermal energy transfer device 200 such as to be able to control a flow rate Φ of a fluid between the thermal energy source 100 and the thermal energy transfer device 200. According to various embodiments, the flow control device 10 controls the flow rate Φ of the fluid using a valve V /damper D arranged in the supply fluid transportation line 410 and/or the return fluid transportation line 420 of the primary fluid circuit 400 connecting the thermal energy source 100 and the thermal energy transfer device 200. Alternatively, or additionally, a pump/ fan 450 may be provided to induce the flow of fluid through the primary fluid circuit 400.

[0078] In a first step **530** of the method, a flow rate of the fluid in the primary fluid circuit 400 is determined (continuously, pseudo-continuously and/or at intervals during operation of the HVAC system 1). In a step **S40,** a temperature of a fluid in the secondary fluid circuit 500 is determined. In a substep **S42** of step S40, a supply temperature T2s is measured in a supply fluid transportation 510 line of the secondary fluid circuit 500. In a further substep **S44** of step S40, simultaneous or sequential to substep S42, a return temperature T2r is measured in a return fluid transportation line 520 of the secondary fluid circuit 500.

[0079] Having determined the flow rate of the fluid in the primary fluid circuit 400 and the temperature of a fluid in the secondary fluid circuit 500, in a step **S90,** the flow rate Φ of the fluid in the primary fluid circuit 400 is controlled as a function of the temperature of the fluid in the secondary fluid circuit 500. The flow rate Φ of the fluid in the primary fluid circuit 400 is controlled using a flow control device 10 arranged in the primary fluid circuit 400, in particular by generating control signals causing the actuator A to drive the valve V and/or damper D, respectively by generating control signals varying the power of the pump P and/or fan F.

[0080] Figure 5 shows a flowchart illustrating steps of a further embodiment of the method of operating an HVAC system 1 according to the present disclosure, enabling limiting the rate and/or amount of thermal energy delivered to consumers.

[0081] In a step **S50,** the supply temperature Ts and the return temperature Tr of the fluid in the primary fluid circuit 400 are measured. In a substep **S52** of step S50, the supply temperature Ts is measured in supply fluid transportation line 410 connecting the thermal energy source 100 and the thermal energy transfer device 200. In a substep **S54,** simultaneous or sequential to substep S52, a return temperature Tr is measured in a return fluid transportation line 420 connecting the thermal energy transfer device with the thermal energy source 100.

[0082] Based on the determined supply temperature Ts, return temperature Tr and flow rate Φ of the fluid in the primary fluid circuit 400, in a step **S60,** a rate P and/or amount E of thermal energy transfer between the primary fluid circuit 400 and the secondary fluid circuit 500 is determined.

[0083] In a substep **S92** of step S90, the flow rate Φ of the fluid in the primary fluid circuit 400 is controlled further to ensuring that the rate P and/or amount of thermal energy transfer E between the primary fluid circuit 400 and the secondary fluid circuit 500 does not exceed an energy transfer threshold E_{max}, P_{max}.

[0084] Figure 6 shows a flowchart illustrating steps of even further embodiments of the method of operating an HVAC system 1 according to the present disclosure.

[0085] In an additional or alternative substep **S94** of step S90, the flow rate of the fluid in the primary fluid circuit is controlled further ensuring that the return temperature in the primary fluid circuit 400 is above a minimum return temperature threshold Tr_{min}. Alternatively, or additionally the flow rate of the fluid in the primary fluid circuit is controlled further ensuring that the return temperature is below a maximum return temperature threshold Tr_{max}. Ensuring that the return temperature is below a maximum return temperature threshold....

[0086] Alternatively, or additionally, substep **S95** of step S90, the flow rate of the fluid in the primary fluid circuit is controlled to maintain a target temperature differential $\Delta T2$ between the supply temperature T2s and the return temperature T2r in the secondary fluid circuit 500. Controlling the flow rate of the fluid such as to maintain a target temperature differential $\Delta T2$ in the secondary fluid circuit 500 comprises one or more of:

- Maintaining a target temperature differential as a function of the supply temperature T2s, advantageous as it enables accounting for different levels of supply temperatures. Compared to a fixed temperature differential, a target temperature differential $\Delta T2$ as a function of the supply temperature T2s enables increased efficiency and ensures the system is also optimized in partial load.

- Maximizing the temperature differential, advantageous in particular in HVAC systems wherein minimizing the flow of the fluid is desired, e.g. when the fluid needs to be conveyed over long distances/ great differences in elevation and/or in case billing of energy costs is based on volume of supplied fluid.

- Maintain a predefined return temperature range in the secondary fluid circuit 500, advantageous in particular in HVAC systems where the return temperature should not exceed a set threshold.

[0087] Alternatively, or additionally, substep **S68** of step S90, the flow rate of the fluid in the primary fluid circuit is controlled ensuring that the flow rate is above an operational flow rate threshold of the thermal energy transfer device.

[0088] Alternatively, or additionally, substep **S97** of step S90, the flow rate of the fluid in the primary fluid circuit is controlled further such as to ensure that a temperature differential ΔT between the supply temperature Ts and the return temperature Tr of the fluid in the primary fluid circuit 400 - does not fall below a minimum temperature differential Δ_{Tmin} and/or does not exceed a maximum temperature differential ΔT_{max}.

[0089] Alternatively, or additionally, substep **S98** of step S90, the flow rate of the fluid in the primary fluid circuit is controlled further as a function of a thermal energy demand of the thermal energy transfer device.

List of reference numerals

HVAC system	1
flow control device	10
processing unit (of flow control device)	20
temperature sensor device	22s
first temperature sensor (of temperature sensor device 22s)	S1s
second temperature sensor (of temperature sensor device 22s)	S2s
further temperature sensor device	22p
first temperature sensor (of further temperature sensor device 22p)	S1p
second temperature sensor (of further temperature sensor device 22s	S2p
flow rate sensor device	24p
further flow rate sensor device	24s
communication interface	26
data store	27
metering unit	30
display	32
thermal energy source	100
thermal energy transfer device	200
thermal energy consumer	300
primary fluid circuit	400
pump/ fan	450
supply fluid transportation line	410
return fluid transportation line	420
flow rate (in primary fluid circuit)	Φ
flow rate (in secondary fluid circuit)	$\Phi 2$
operational flow rate threshold	Φ_{min}
maximum flow rate threshold	Φ_{max}
supply temperature (in primary fluid circuit)	Ts
minimum return temperature threshold	Tr_{min}
maximum return temperature threshold	Tr_{max}
return temperature (in primary fluid circuit)	Tr

(continued)

temperature differential (in primary fluid circuit)	ΔT
minimum temperature differential (in primary fluid circuit)	ΔT_{min}
maximum temperature differential (in primary fluid circuit)	ΔT_{max}
secondary fluid circuit	500
supply fluid transportation line (in secondary fluid circuit)	510
return fluid transportation line (in secondary fluid circuit)	520
further control unit	530
supply temperature (in secondary fluid circuit)	T2s
return temperature (in secondary fluid circuit)	T2r
target temperature differential (in secondary fluid circuit)	$\Delta T2$
remote computer	1000
rate of thermal energy transfer	P
amount of thermal energy transfer	E
energy transfer threshold	P_{max}, E_{max}, Emax

Claims

1. Method of operating an HVAC system (1) comprising a thermal energy transfer device (200) fluidically connected to a thermal energy source (100) by a primary fluid circuit (400) and further fluidically connected to thermal energy consumer(s) (300) by a secondary fluid circuit (500), the method comprising:

   - determining a flow rate (Φ) of a fluid in the primary fluid circuit (400);
   - determining a temperature of a fluid in the secondary fluid circuit (500); and
   - controlling, by a flow control device (10) arranged in the primary fluid circuit (400), the flow rate (Φ) of the fluid in the primary fluid circuit (400) using the temperature of the fluid in the secondary fluid circuit (500).

2. The method according to claim 1, further comprising:

   - determining a supply temperature (Ts) and a return temperature (Tr) of the fluid in the primary fluid circuit (400);
   - determining a rate (P) and/or amount of thermal energy transfer (E) between the primary fluid circuit (400) and the secondary fluid circuit (500) based on the supply temperature (Ts), the return temperature (Tr) and the flow rate (Φ) of the fluid in the primary fluid circuit (400); and
   - controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) further to ensure that the rate (P) and/or amount of thermal energy transfer (E) between the primary fluid circuit (400) and the secondary fluid circuit (500) does not exceed an energy transfer threshold (P_{max}, E_{max}).

3. The method according to claim 1 or 2, further comprising controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) further to ensure that the return temperature (Tr) is above a minimum return temperature threshold (Tr_{min}) or below a maximum return temperature threshold (Tr_{max}).

4. The method according to one of the claims 1 to 3, wherein:

   - determining the temperature of the fluid in the secondary fluid circuit (500) comprises determining a supply temperature (T2s) and a return temperature (T2r) within the secondary fluid circuit (500) and
   - controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) using the temperature of the fluid in the secondary fluid circuit (500) comprises maintaining a target temperature differential ($\Delta T2$) between the supply temperature (T2s) and the return temperature (T2r) in the secondary fluid circuit (500).

5. The method according to one of the claims 1 to 4, further comprising controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) to ensure that the flow rate (Φ) is above an operational flow rate threshold (Φ_{min}) of the thermal energy transfer device (200) and/or controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) to ensure that the flow rate (Φ) is below a maximum flow rate threshold (Φ_{max}).

6. The method according to one of the claims 2 to 5, further comprising controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) such as to ensure that a temperature differential between (ΔT) the supply temperature (Ts) and the return temperature (Tr) of the fluid in the primary fluid circuit (400) does not fall below a minimum temperature differential (ΔT_{min}) and/or does not exceed a maximum temperature differential (ΔT_{max}).

7. The method according to one of the claims 1 to 6, further comprising:

- receiving, by the flow control device (10), a signal indicative of a thermal energy demand of the thermal energy consumer (300); and
- controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) further using the thermal energy demand.

8. A flow control device (10) comprising:

- a valve (V) and/or a damper (D) drivingly connected to an actuator (A) and/or interface communicatively connectable to a pump (P) and/or a fan (F) configured to control a flow rate (Φ) of a fluid in a primary fluid circuit (400);
- a flow rate sensor device (24p) configured, respectively arranged to determine the flow rate (Φ) of the fluid in a primary fluid circuit (400) and/or an interface for receiving sensor data from a flow rate sensor device (24p) configured, respectively arranged to determine the flow rate (Φ) of the fluid in the primary fluid circuit (400);
- a temperature sensor device (22s) configured, respectively arranged to determine a temperature of a fluid in a secondary fluid circuit (500) and/or an interface for receiving sensor data from a temperature sensor device (22s) configured, respectively arranged to determine a temperature of a fluid in the secondary fluid circuit (500); and
- a processing unit (20) communicatively configured to control the flow rate (Φ) of the fluid in the primary fluid circuit (400) using the temperature of the fluid in the secondary fluid circuit (500).

9. The flow control device (10) according to claim 8, further comprising:

- a further temperature sensor device (22p) configured, respectively arranged to determine the supply temperature (Ts) of the fluid and the return temperature (Tr) of the fluid in the primary fluid circuit (400);
- an interface for receiving sensor data from a further temperature sensor device (22p) configured, respectively arranged to determine the supply temperature (Ts) of the fluid and the return temperature (Tr) of the fluid in the primary fluid circuit (400); and
- a metering unit (30) configured to determine a rate (P) and/or amount of thermal energy transfer (E) between the primary fluid circuit (400) and the secondary fluid circuit (500) based on the supply temperature (Ts), the return temperature (Tr) and the flow rate (Φ) of the fluid in the primary fluid circuit (400),

wherein the processing unit (20) is further configured to control the flow rate (Φ) of the fluid in the primary fluid circuit (400) further to ensure that the rate (P) and/or amount of thermal energy transfer (E) between the primary fluid circuit (400) and the secondary fluid circuit (500) does not exceed an energy transfer threshold (P_{max}, E_{max}).

10. The flow control device (10) according to one of the claims 8 or 9, further comprising:

- a further flow rate sensor device (24s) configured, respectively arranged to determine a flow rate ($\Phi 2$) of the fluid in the secondary fluid circuit (500); and/or
- an interface for receiving sensor data from a further flow rate sensor device (24s) configured, respectively arranged to determine a flow rate ($\Phi 2$) of the fluid in the secondary fluid circuit (500),
wherein the processing unit (20) is further configured to determine a thermal energy demand of the thermal energy consumer (300) based on the flow rate ($\Phi 2$) in the secondary fluid circuit (500) and further configured to control the flow rate (Φ) of the fluid in the primary fluid circuit (400) further using the thermal energy demand.

11. The flow control device (10) according to one of the claims 8 to 10, further comprising a communication interface (26) configured to receive a signal indicative of a thermal energy demand of the thermal energy consumer (300), wherein the processing unit (20) is further configured to control the flow rate (Φ) of the fluid in the primary fluid circuit (400) further using the thermal energy demand.

12. The flow control device (10) according to one of the claims 8 to 10, further comprising a communication interface (26) configured to receive, from a remote computer, control signals for controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400).

13. An HVAC system (1) comprising:

- a thermal energy source (100);
- a thermal energy transfer device (200);
- a primary fluid circuit (400) comprising:

    - a supply fluid transportation line (410) arranged to transport a fluid from the thermal energy source (100) to the thermal energy transfer device (200);
    - a return fluid transportation line (420) arranged to transport the fluid from the thermal energy transfer device (200) to the thermal energy source (100);

- a thermal energy consumer (300) fluidically connected with the thermal energy transfer device (200) by a secondary fluid circuit (500), the secondary fluid circuit (500) comprising:

    - a supply fluid transportation line (510) arranged to transport a fluid from the thermal energy transfer device (200) to the thermal energy consumer (300); and
    - a return fluid transportation line (520) arranged to transport the fluid from the thermal energy consumer (300) to the thermal energy transfer device (200); and

- a flow control device (10) according to one of the claims 8 to 11, arranged to control a flow rate (Φ) of the fluid in the primary fluid circuit (400) ;

the HVAC system (1) being configured to carry out the method according to one of the claims 1 to 7.

14. The HVAC system (1) according to claim 12,further comprising a remote computer (1000) communicatively connected with the flow control device (10), the remote computer (1000) being configured to transmit control signals for controlling the flow rate (Φ) of the fluid in the primary fluid circuit (400) to the flow control device (10).

15. Computer program product comprising instructions which, when executed by a processing unit (20) of a flow control device (10),cause the flow control device (10) to carry out the method according to one of the claims 1 to 7.

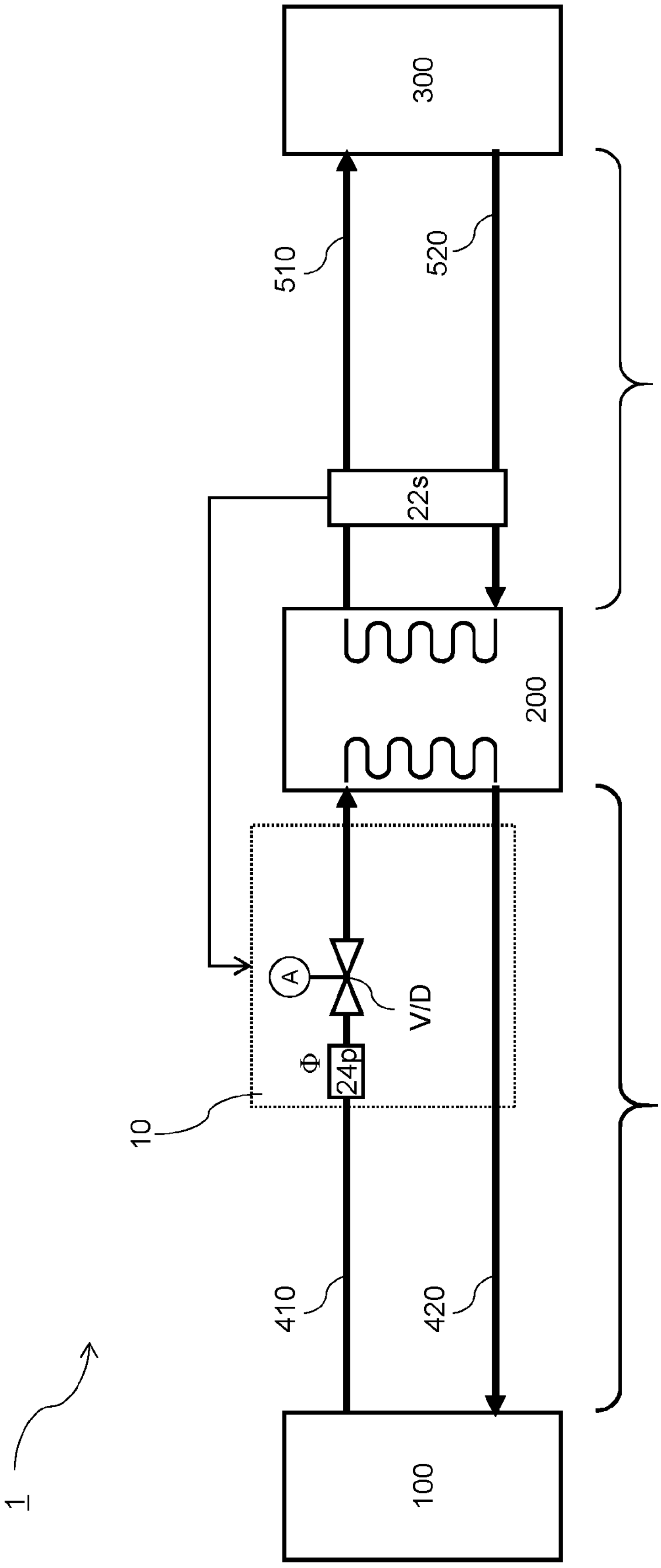

Fig. 1

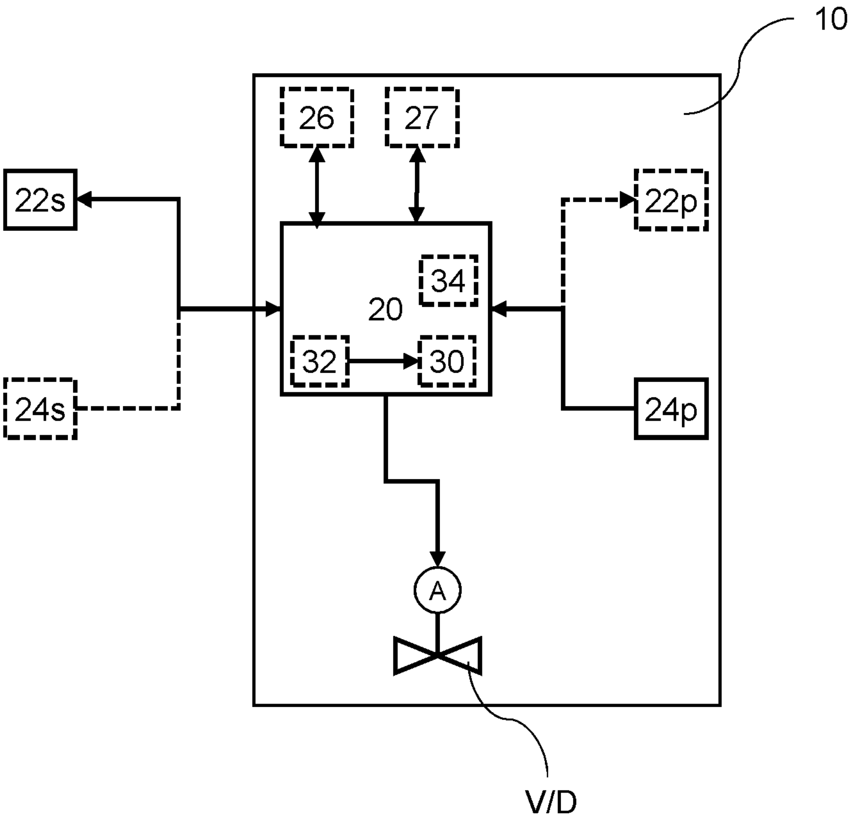

Fig. 2

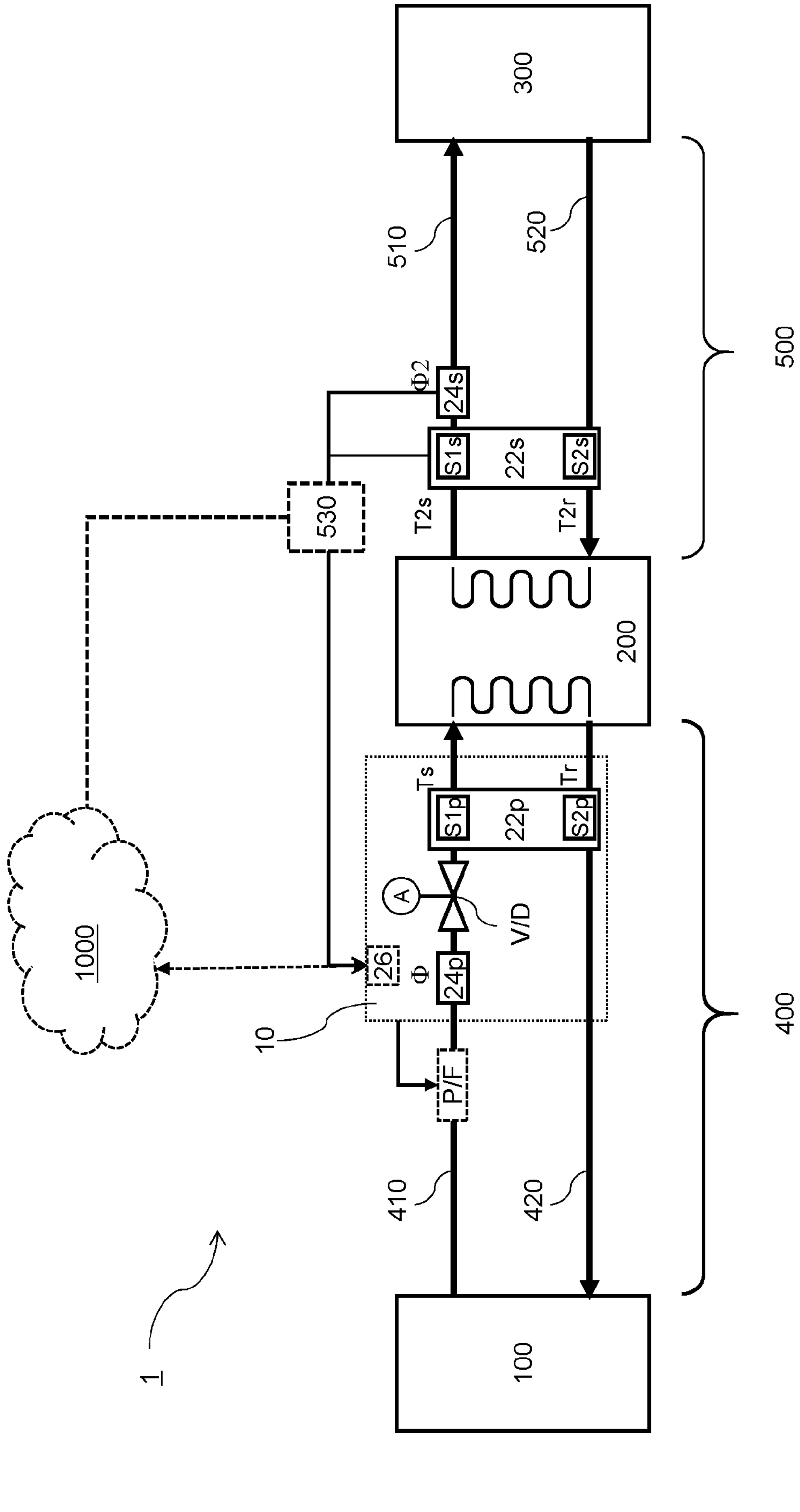
300
510
520
500
Φ2
24s
S1s
22s
S2s
530
T2s
T2r
200
1000
Ts
Tr
S1p
22p
S2p
A
V/D
26
Φ
24p
10
P/F
400
410
420
1
100

Fig. 3

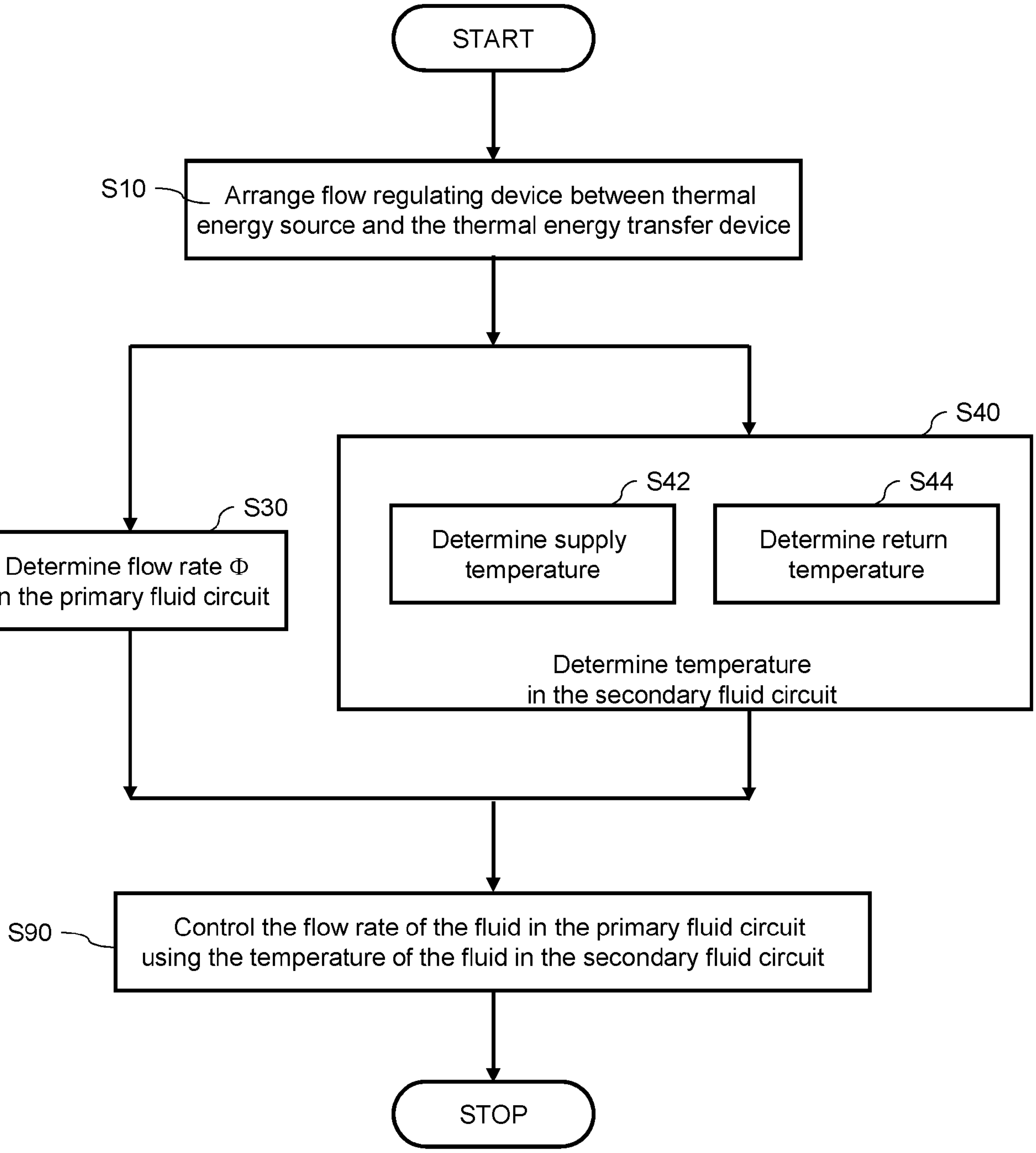
START
S10
Arrange flow regulating device between thermal energy source and the thermal energy transfer device
S30
Determine flow rate Φ in the primary fluid circuit
S40
S42
Determine supply temperature
S44
Determine return temperature
Determine temperature in the secondary fluid circuit
S90
Control the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit
STOP

Fig. 4

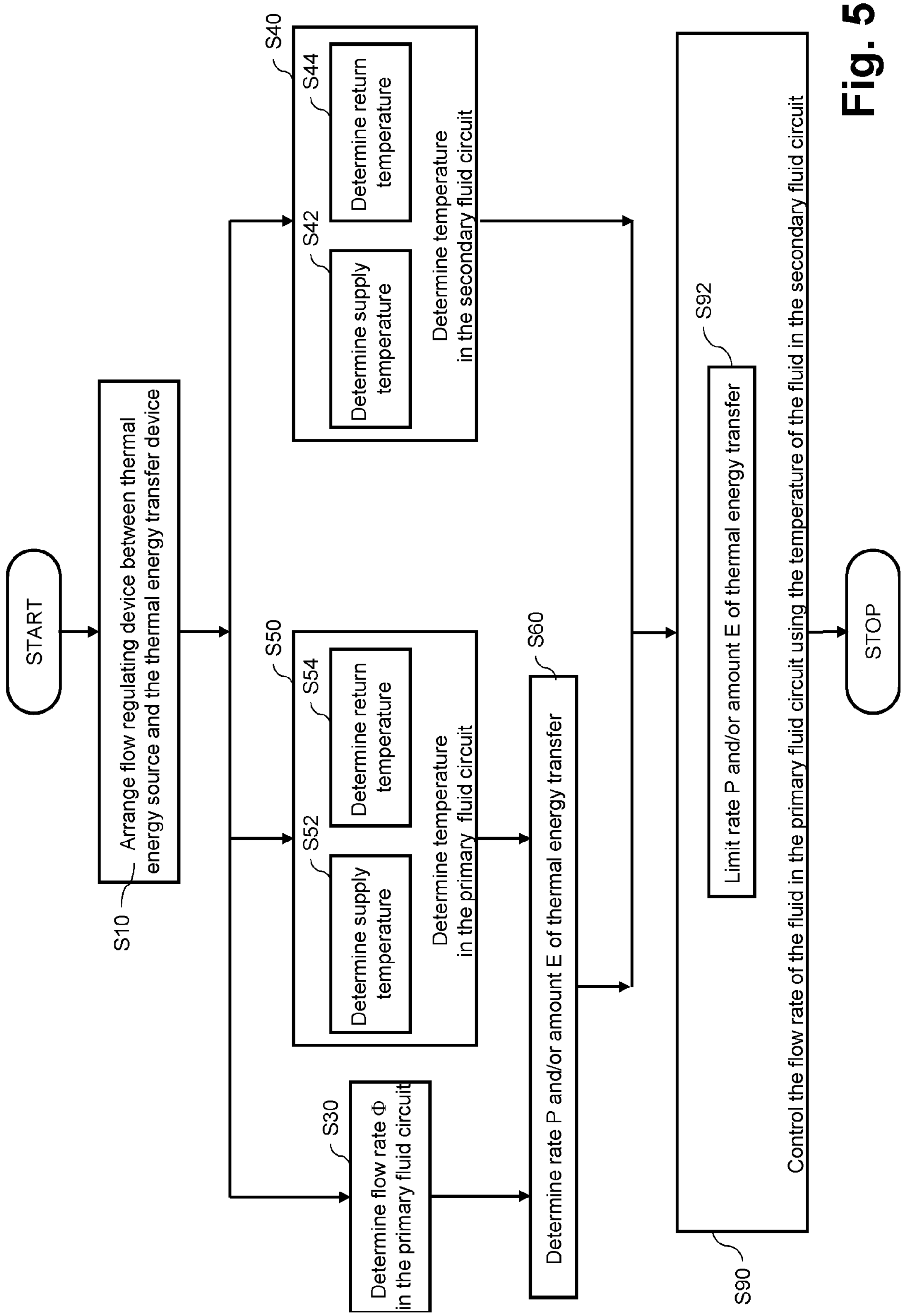
START
S10
Arrange flow regulating device between thermal energy source and the thermal energy transfer device
S30
Determine flow rate Φ in the primary fluid circuit
S50
S52
Determine supply temperature
S54
Determine return temperature
Determine temperature in the primary fluid circuit
S40
S42
Determine supply temperature
S44
Determine return temperature
Determine temperature in the secondary fluid circuit
S60
Determine rate P and/or amount E of thermal energy transfer
S90
Control the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit
S92
Limit rate P and/or amount E of thermal energy transfer
STOP

Fig. 5

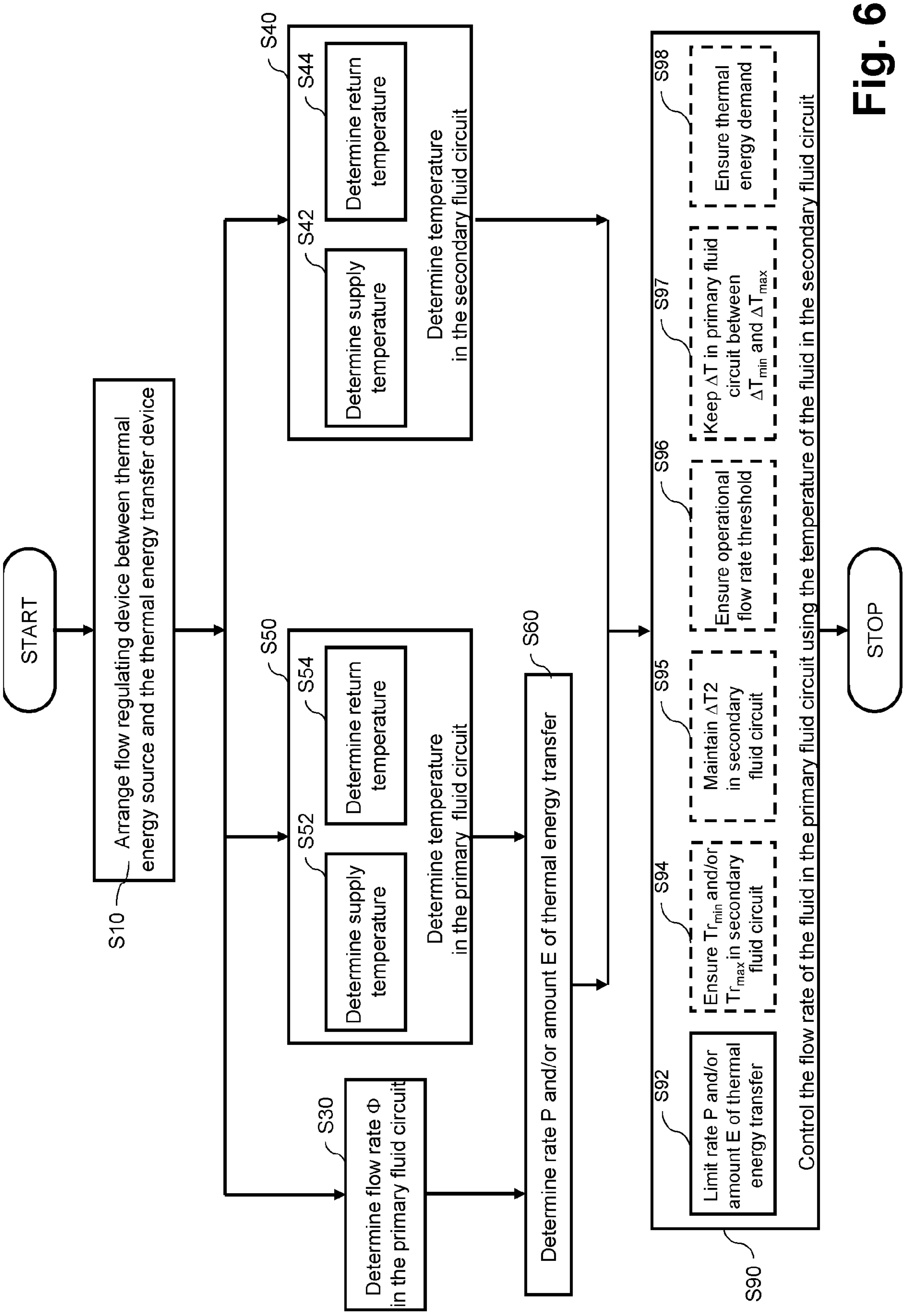
START
Arrange flow regulating device between thermal energy source and the thermal energy transfer device
S10
Determine flow rate Φ in the primary fluid circuit
S30
Determine supply temperature
S52
Determine return temperature
S54
Determine temperature in the primary fluid circuit
S50
Determine supply temperature
S42
Determine return temperature
S44
Determine temperature in the secondary fluid circuit
S40
Determine rate P and/or amount E of thermal energy transfer
S60
Limit rate P and/or amount E of thermal energy transfer
S92
Ensure Tr_{min} and/or Tr_{max} in secondary fluid circuit
S94
Maintain ΔT2 in secondary fluid circuit
S95
Ensure operational flow rate threshold
S96
Keep ΔT in primary fluid circuit between ΔT_{min} and ΔT_{max}
S97
Ensure thermal energy demand
S98
Control the flow rate of the fluid in the primary fluid circuit using the temperature of the fluid in the secondary fluid circuit
S90
STOP

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 0149

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2014/041848 A1 (KATO YOHEI [JP] ET AL) 13 February 2014 (2014-02-13) * paragraphs [0025] - [0027], [0032], [0097]; figure 1 *	1,3-8, 11-15 2,9,10	INV. F24F5/00 F24D19/10 F24F11/70 F24F11/83 F24D10/00 ADD. F24F140/20
Y	EP 2 927 620 A1 (MITSUBISHI ELECTRIC CORP [JP]) 7 October 2015 (2015-10-07) * paragraphs [0043], [0050]; figures 2-4 *	2,9	
Y	CN 112 856 724 A (DING YI; XU SHIYU) 28 May 2021 (2021-05-28) * paragraphs [0055], [0063] - [0072]; figure 1 *	10	
X	EP 3 531 035 A1 (MITSUBISHI ELECTRIC CORP [JP]) 28 August 2019 (2019-08-28) * paragraphs [0011] - [0025]; figure 2 *	1,8,15	

TECHNICAL FIELDS SEARCHED (IPC)

F24F
F24D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 September 2024	Blot, Pierre-Edouard

CATEGORY OF CITED DOCUMENTS

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