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(54) **THERMAL ENERGY BALANCING DEVICE**

(57) A thermal energy balancing device is provided which is connected to a thermal energy circuit (100) comprising a hot conduit (120) configured to allow heat transfer liquid of a first temperature to flow therethrough, and a cold conduit (140) configured to allow heat transfer liquid of a second temperature to flow therethrough. The second temperature is lower than the first temperature.

The thermal energy balancing device comprises: a liquid-to-air heat exchanger (600) comprising a liquid phase primary side (610) and a gas phase secondary side (620); and a valve arrangement (500) configured to selectively set the thermal energy balancing device into a heat exhale mode and into a heat inhale mode.

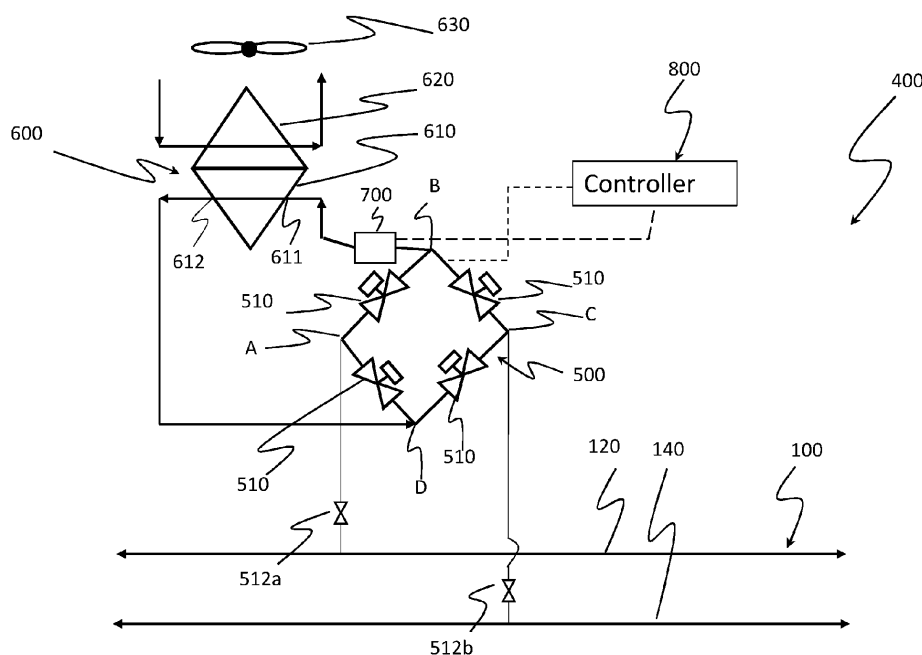


Fig. 2

Description

Field of the invention

[0001] The invention relates to a thermal energy balancing device to be connected to a thermal energy circuit comprising a hot and a cold conduit.

Background of the invention

[0002] Nearly all large developed cities in the world have at least two types of energy grids incorporated in their infrastructures; one grid for providing electrical energy and one grid for providing space heating and hot tap water preparation. Today a common grid used for providing space heating and hot tap water preparation is a gas grid providing a burnable gas, typically a fossil fuel gas. The gas provided by the gas grid is locally burned for providing space heating and hot tap water. An alternative for the gas grid for providing space heating and hot tap water preparation is a district heating grid. Also, the electrical energy of the electrical energy grid may be used for space heating and hot tap water preparation. Also, the electrical energy of the electrical energy grid may be used for space cooling. The electrical energy of the electrical energy grid is further used for driving refrigerators and freezers.

[0003] Accordingly, traditional building heating and cooling systems use primary high-grade energy sources such as electricity and fossil fuels or an energy source in the form of industrial waste heat to provide space heating and/or cooling, and to heat or cool water used in the building. Furthermore, it has been increasingly common to also install a district cooling grid in cities for space cooling. The process of heating or cooling the building spaces and water converts this high-grade energy into low grade waste heat with high entropy which leaves the building and is returned to the environment.

[0004] In this kind of existing systems, it is well known to use cooling towers to exhale heat from the system and let it diminish into the air, to thereby get rid of waste heat. This is especially used in regions having a hot climate during most of the 12 months. However, also these regions have, at least during a part of the year, a lower temperature where there may be a need for an active supply of heat into the system. Examples of such regions are those where the winter temperature rarely go below 10 degrees Celsius. There is however no real economical and climate smart solutions of how to make this without involving high grade energy sources.

[0005] Hence, there is a need for improvements in how to provide flexible heating and cooling to a city and especially a versatile system that may be based on existing systems of the type described above.

Summary of the invention

[0006] It is an object of the present invention to solve

at least some of the problems mentioned above.

[0007] According to a first aspect, a thermal energy balancing device is provided. The thermal energy balancing device is connected to a thermal energy circuit comprising a hot conduit configured to allow heat transfer liquid of a first temperature to flow therethrough, and a cold conduit configured to allow heat transfer liquid of a second temperature to flow therethrough, the second temperature being lower than the first temperature, and wherein the thermal energy balancing device comprises:

a liquid-to-air heat exchanger comprising a liquid phase primary side and a gas phase secondary side, and

a valve arrangement configured to selectively set the thermal energy balancing device into a heat exhale mode wherein heat transfer liquid is directed to flow from the hot conduit via the primary side of the heat exchanger to the cold conduit, and into a heat inhale mode wherein heat transfer liquid is directed to flow from the cold conduit via the primary side of the heat exchanger to the hot conduit.

[0008] Accordingly, a thermal energy balancing device is provided which, as a part thereof, uses a hot conduit and a cold conduit forming part of a thermal energy circuit. The two conduits do both have a flow of a heat transfer liquid therethrough, but with an inherent temperature difference. The thermal energy circuit may by way of example be a bidirectional grid, such as a grid known as ectogrid™ which connects buildings with different needs and which balances residual thermal energy flows between the buildings. The two conduits are each, via an intermediate valve arrangement, connected to the liquid primary side of a liquid-to air heat exchanger. The thermal energy balancing device may be set, either into a heat exhale mode or into a heat inhale mode, depending on if there is a need to exhale or inhale heat from or to the thermal energy circuit. In the event of a heat exhale mode, the heat transfer fluid from the hot conduit is allowed to be transferred via the primary side of the heat changer to the cold conduit during which transfer the temperature of the hotter heat transfer fluid will be lowered before being fed to and intermixed with the heat transfer fluid in the cold conduit. Heat will be exhaled from the heat transfer fluid while passing across the interface between the primary side and the secondary side of the liquid-to-air heat exchanger. Correspondingly, in the event of a heat inhale mode, the colder heat transfer fluid from the cold conduit is allowed to be transferred via the primary side of the heat changer to the hot conduit during which transfer the temperature of the colder heat transfer fluid will be increased before being fed to and intermixed with the heat transfer fluid in the hot conduit. Heat will be inhaled while passing across the interface between the primary side and the secondary side of the liquid-to-air heat exchanger.

[0009] The liquid-to-air heat exchanger may, as such

be part of an existing infrastructure, such as an existing cooling tower(s) or a fan convector which is used for heating and/or cooling.

[0010] The fluid flow between the hot and cold conduits is controlled by a valve arrangement. The valve arrangement may have a design with a plurality of valves which, depending on their mutual setting, allow the flow of heat transfer fluid to and from the two conduits to be controlled. The valves may be of the on/off type.

[0011] The liquid-to-air heat exchanger is preferably a water-to-air heat exchanger. It is however to be understood that other liquids than water may be used.

[0012] Accordingly, and in summary, the invention provides a solution where a double functionality may be achieved which offers not only the ability to exhale heat but also to inhale heat depending on e.g. season or different local clients need.

[0013] The liquid phase primary side of the liquid-to-air heat exchanger may comprise an inlet and an outlet, and the valve arrangement may be configured to direct a flow of heat transfer liquid from the inlet to the outlet when the valve arrangement is set into the heat exhale mode and when the valve arrangement is set into the heat inhale mode. Accordingly, one and the same inlet is used, no matter mode. Only the conduits from which the liquid is fed from and returned to are altered, and this is made by controlling the valves of the valve arrangement.

[0014] The thermal energy balancing device may further comprise a fan configured to produce an air flow at the gas phase secondary side of the liquid-to-air heat exchanger. The fan may be used to generate a turbulent air flow across the interface between the gas phase secondary side and the liquid phase primary side of the heat exchanger. Thereby heat transfer between the primary and secondary sides may be facilitated, no matter if it is to promote a heat exhaling effect or a heat inhaling effect.

[0015] The fan may be configured to provide an air flow counter to the flow direction on the primary liquid side.

[0016] The fan may be configured to provide an air flow counter to the flow direction on the primary liquid side no matter if the thermal energy balancing device is set into the heat exhale mode or into the heat inhale mode. Thus, there is no need to actively control the fan separately.

[0017] The thermal energy balancing device may further comprise a regulator and a pressure difference determining device adapted to determine a local pressure difference, Δp_{local} , between a local hot conduit pressure, p_h , of heat transfer liquid of the hot conduit and a local cold conduit pressure, p_c , of heat transfer liquid of the cold conduit, $\Delta p_{\text{local}} = p_h - p_c$; and wherein the regulator is configured to, based on the determined local pressure difference, regulate the flow of heat transfer liquid between the hot and cold conduits.

[0018] The pressure difference determining device is configured to sense local pressure in the hot conduit and in the cold conduit respectively and determine a difference between the two pressures. The pressure differ-

ence determining device may also be configured to determine if the determined local pressure difference is acceptable in view of a predetermined set value.

[0019] The local pressure in the two conduits will vary depending on where in the thermal energy circuit the pressure is measured. The local pressure differences are the result of different client's activity and needs. Examples of different clients are different households, different offices or different stores, which all have different needs which also vary over time and across a day.

[0020] The regulator may be provided as a pump which is arranged in a position between the hot conduit and the cold conduit. The regulator may be arranged either in a position before the inlet to the primary side of the liquid-to-air heat exchanger, or after the outlet from the primary side of the liquid-to-air heat exchanger. The purpose of the regulator is to promote the flow of liquid to the heat exchanger in the event the determined local pressure difference between the hot conduit and the cold conduit should be determined to be below a set value. In the event the determined local pressure difference instead should be determined to be above the set value, the regulator may instead be set into a passive mode and instead act as an open valve allowing a flow of heat transfer liquid to pass therethrough.

[0021] The thermal energy balancing device may further comprise a controller connected to one or more of the pressure difference determining device, the regulator and the valve arrangement.

[0022] A further scope of applicability of the present invention will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

[0023] Hence, it is to be understood that this invention is not limited to the particular component parts of the device described as the realization of the device may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only, and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a unit" or "the unit" may include several devices, and the like. Furthermore, the words "comprising", "including", "containing" and similar wordings does not exclude other elements or steps.

Brief description of the drawings

[0024] These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing embodiments of the

invention. The figures are provided to illustrate the general structures of embodiments of the present invention. Like reference numerals refer to like elements throughout.

Fig. 1 is a schematic diagram of a district thermal energy distribution system.

Fig. 2 is a schematic diagram of a thermal energy balancing device according to the invention.

Fig. 3A is a schematic diagram of a thermal energy balancing device according to the invention as set into a heat exhale mode.

Fig. 3B is a schematic diagram of a thermal energy balancing device according to the invention as set into a heat inhale mode.

Fig. 4 is a schematic diagram of a thermal energy balancing device according to the invention disclosing a first embodiment of a pressure determining device.

Fig. 5 is a schematic diagram of a thermal energy balancing device according to the invention disclosing a second embodiment of a pressure determining device.

Detailed description

[0025] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and to fully convey the scope of the invention to the skilled person.

[0026] To facilitate the understanding of the invention, reference is made to Fig. 1 which discloses one example of a district thermal energy distribution system 1 according to prior art in which the invention may be applicable.

[0027] The district thermal energy distribution system 1 comprises a thermal energy circuit 10 and a plurality of buildings 5. The plurality of buildings 5 are thermally coupled to the thermal energy circuit 10. The thermal energy circuit 10 is arranged to circulate and store thermal energy in heat transfer liquid flowing through the thermal energy circuit 10.

[0028] According to one embodiment the heat transfer liquid comprises water. However, according to other embodiments other heat transfer liquid may be used. Some non-limiting examples are ammonia, oils, alcohols and anti-freezing liquids such as glycol. The heat transfer liquid may also comprise a mixture of two or more of the heat transfer liquids mentioned above.

[0029] The thermal energy circuit 10 comprises two conduits 12, 14 for allowing flow of heat transfer liquid therethrough. The temperature of the heat transfer liquid of the two conduits 12, 14 is set to be different. A hot conduit 12 in the thermal energy circuit 10 is configured

to allow heat transfer liquid of a first temperature to flow therethrough. A cold conduit 14 in the thermal energy circuit 10 is configured to allow heat transfer liquid of a second temperature to flow therethrough. The second temperature is lower than the first temperature.

[0030] In case heat transfer liquid is water, a suitable normal operation hot temperature range for heat transfer liquid in the hot conduit 12 is between 5 and 45°C and a suitable normal operation cold temperature range for heat transfer liquid in the cold conduit 14 is between 0 and 40°C. A suitable temperature difference between the first and second temperatures is in the range of 5-16°C, preferably in the range of 7-12°C, more preferably 8-10°C.

[0031] Preferably, the system is set to operate with a sliding temperature difference which varies depending on the climate. Preferably, the sliding temperature difference is fixed. Hence, the temperature difference is always set to momentarily slide with a fixed temperature difference.

[0032] The hot conduit 12 and the cool conduit 14 are separate. The hot conduit 12 and the cool conduit 14 may be arranged in parallel. The hot conduit 12 and the cool conduit 14 may be arranged as closed loops of piping. The hot conduit 12 and the cool conduit 14 are fluidly interconnected at the buildings 5 for allowing of thermal energy transfer to and from the buildings 5.

[0033] According to one embodiment the two conduits 12, 14 of the thermal energy circuit 10 are dimensioned for pressures up to 1 MPa (10 bar). According to other embodiments the two conduits 12, 14 of the thermal energy circuit 10 may be dimensioned for pressures up to 0.6 MPa (6 bar) or for pressures up to 1.6 MPa (16 bar).

[0034] Each building 5 comprise at least one of one or more local thermal energy consumer assemblies 20 and one or more local thermal energy generator assemblies 30. Hence, each building comprises at least one local thermal energy consumer assembly 20 or at least one local thermal energy generator assembly 30. One specific building 5 may comprise more than one local thermal energy consumer assembly 20. One specific building 5 may comprise more than one local thermal energy generator assembly 30. One specific building 5 may comprise both a local thermal energy consumer assembly 20 and a local thermal energy generator assembly 30.

[0035] The local thermal energy consumer assembly 20 is acting as a thermal sink. Hence, the local thermal energy consumer assembly 20 is arranged to remove thermal energy from the thermal energy circuit 10. Or in other words, the local thermal energy consumer assembly 20 is arranged to transfer thermal energy from heat transfer liquid of the thermal energy circuit 10 to surroundings of the local thermal energy consumer assembly 20. This is achieved by transferring thermal energy from heat transfer liquid taken from the hot conduit 12 to surroundings of the local thermal energy consumer assembly 20, such that heat transfer liquid that is returned to the cold conduit 14 has a temperature lower than the first tem-

perature and preferably a temperature equal to the second temperature.

[0036] The local thermal energy generator assembly 30 is acting as a thermal source. Hence, the local thermal energy generator assembly 30 is arranged to deposit thermal energy to the thermal energy circuit 10. Or in other words, the local thermal energy generator assembly 30 is arranged to transfer thermal energy from its surroundings to heat transfer liquid of the thermal energy circuit 10. This is achieved by transferring thermal energy from surroundings of the local thermal energy generator assembly 30 to heat transfer liquid taken from the cold conduit 12, such that the heat transfer liquid that is returned to the hot conduit 12 has a temperature higher than the second temperature and preferably a temperature equal to the first temperature.

[0037] The one or more local thermal energy consumer assemblies 20 may be installed in the buildings 5 as local heaters for different heating needs. As a non-limiting example, a local heater may be arranged to deliver space heating or hot tap hot water preparation. Alternatively, or in combination, the local heater may deliver pool heating or ice- and snow purging. Hence, the local thermal energy consumer assembly 20 is arranged for deriving heat from heat transfer liquid of the hot conduit 12 and creates a cooled heat transfer liquid flow into the cold conduit 14. Hence, the local thermal energy consumer assembly 20 fluidly interconnects the hot and cool conduits 12, 14 such that hot heat transfer liquid can flow from the hot conduit 12 through the local thermal energy consumer assembly 20 and then into the cool conduit 14 after thermal energy in the heat transfer liquid has been consumed by the local thermal energy consumer assembly 20. The local thermal energy consumer assembly 20 operates to draw thermal energy from the hot conduit 12 to heat the building 5 and then deposits the cooled heat transfer liquid into the cool conduit 14.

[0038] The one or more local thermal energy generator assemblies 30 may be installed in different buildings 5 as local coolers for different cooling needs. As a non-limiting example, a local cooler may be arranged to deliver space cooling or cooling for freezers and refrigerators. Alternatively, or in combination, the local cooler may deliver cooling for ice rinks and ski centers or ice- and snow making. Hence, the local thermal energy generator assembly 30 is deriving cooling from heat transfer liquid of the cold conduit 14 and creates a heated heat transfer liquid flow into the hot conduit 12. Hence, the local thermal energy generator assembly 30 fluidly interconnects the cold and hot conduits 14, 12 such that cold heat transfer liquid can flow from the cold conduit 14 through the local thermal energy generator assembly 30 and then into the hot conduit 12 after thermal energy has been generated into the heat transfer liquid by the local thermal energy generator assembly 30. The local thermal energy generator assembly 30 operates to extract heat from the building 5 to cool the building 5 and deposits that extracted heat into the hot conduit 12.

[0039] The local thermal energy consumer assembly 20 is selectively connected to the hot conduit 12 via a non-disclosed valve and a non-disclosed pump. Upon selecting the connection of the local thermal energy consumer assembly 20 to the hot conduit 12 to be via the valve, heat transfer liquid from the hot conduit 12 is allowed to flow into the local thermal energy consumer assembly 20. Upon selecting the connection of the local thermal energy consumer assembly 20 to the hot conduit 12 to be via the pump, heat transfer liquid from the hot conduit 12 is pumped into the local thermal energy consumer assembly 20.

[0040] The local thermal energy generator assembly 30 is selectively connected to the cold conduit 14 via a non-disclosed valve and a non-disclosed pump. Upon selecting the connection of the local thermal energy generator assembly 30 to the cold conduit 14 to be via the valve, heat transfer liquid from the cold conduit 14 is allowed to flow into the local thermal energy generator assembly 30. Upon selecting the connection of the local thermal energy generator assembly 30 to the cold conduit 14 to be via the pump, heat transfer liquid from the cold conduit 14 is pumped into the local thermal energy generator assembly 30.

[0041] Preferably, the demand to inhale or exhale thermal energy using the local thermal energy consumer assemblies 20 and the local thermal energy generator assemblies 30 is made at a defined temperature difference. A temperature difference in the range of 5-16°C, preferably in the range of 7-12°C, more preferably 8-10°C corresponds to optimal flows through the system.

[0042] The local pressure difference between the hot and cold conduits 12, 14 may vary along the thermal energy circuit 10. Especially, the local pressure difference between the hot and cold conduits 12, 14 may vary from positive to negative pressure difference seen from one of the hot and cold conduits 12, 14. Hence, sometimes a specific local thermal energy consumer/generator assembly 20, 30 may need to pump heat transfer liquid there through and sometimes the specific local thermal energy consumer/generator assembly 20, 30 may need to let heat transfer liquid flow through there through. Accordingly, it will be possible to let all the pumping within the system 1 to take place in the local thermal energy consumer/generator assemblies 20, 30. Due to the limited flows and pressures needed small frequency-controlled circulation pumps may be used.

[0043] The basic idea of the district thermal energy distribution system 1 as described above and which is illustrated in Fig. 1 is based on the insight by the applicant that modern day cities by them self provide thermal energy that may be reused within the city. The reused thermal energy may be picked up by the district thermal energy distribution system 1 and be used for e.g. space heating or hot tap water preparation. Moreover, increasing demand for space cooling will also be handled within the district thermal energy distribution system 1. Within the district thermal energy distribution system 1 buildings

5 within the city are interconnected and may in an easy and simple way redistribute low temperature waste energy for different local demands.

[0044] In order to balance the thermal energy within the district thermal energy distribution system 1, the system 1 may further comprise a thermal server plant 40. The thermal server plant 40 functions as an external thermal source and/or thermal sink. The function of the thermal server plant 40 is to maintain the temperature difference between the hot and cold conduits 12, 14 of the thermal energy circuit 10. The function of the thermal server plant 40 is further to regulate the pressure difference between the hot and cold conduits 12, 14 of the thermal energy circuit 10.

[0045] Now turning to Fig. 2, the present invention will be discussed. Fig. 2 discloses one embodiment of a thermal energy balancing device 400 which may form part of the prior art system described above with reference to Fig. 1.

[0046] The thermal energy balancing device 400 comprises a valve arrangement 500 and a liquid-to-air heat exchanger 600 which both will be described below.

[0047] The thermal energy balancing device 400 is configured to be connected to a thermal energy circuit 100 which comprises a hot conduit 120 and a cold conduit 140.

[0048] The overall design and function of the thermal energy circuit 100 is the same as that described above with reference to Fig. 1. Thus, the features of the prior art circuit described above are equally applicable and to avoid undue repetition, reference is made to the above. The hot conduit 120 is like in the prior art system configured to allow heat transfer liquid of a first temperature to flow therethrough. Correspondingly, the cold conduit 140 is configured to allow heat transfer liquid of a second temperature to flow therethrough. The second temperature is lower than the first temperature. The flow in the hot conduit 120 and the cold conduit 140 may be bidirectional.

[0049] The heat exchanger 600 is preferably a water-to-air heat exchanger. It is however to be understood that other liquids than water may be used.

[0050] The heat exchanger 600 may by way of example be a fan convector for heating and cooling which as such is well known to the skilled person. The heat exchanger 600 may be part of an existing infrastructure, such as an existing cooling or heating machine in a building.

[0051] The heat exchanger 600 comprises a liquid phase primary side 610 and a gas phase secondary side 620. The liquid phase primary side 610 comprises one inlet 611 and one outlet 612 allowing a flow of heat transfer liquid to pass across the liquid phase primary side 610.

[0052] The inlet 611 and the outlet 612 are connected to the valve arrangement 500. The valve arrangement 500 is arranged in fluid communication with the hot conduit 120 and with the cold conduit 140.

[0053] The connection of the valve arrangement 500

to the hot and cold conduits 120, 140 may be made via service valves 512a, 512b. The service valves 512a, 512b may be used for connecting and disconnecting the valve arrangement 500 and thereby the heat exchanger 600 to/from the thermal energy circuit 100.

[0054] The gas phase secondary side 620 of the heat exchanger 600 may comprise a fan 630. The fan 630 is configured to produce an air flow at the gas phase secondary side 620 of the heat exchanger 600. The fan 630 will be further described below.

[0055] The valve arrangement 500 comprises four valves 510 that are interconnected in series to form a closed loop. Each valve 510 is configured as a valve of the on/off-type. It is however to be understood that other valve types are equally applicable.

[0056] The closed loop comprises four connections points A, B, C, D, with one connection point between two adjacent valves 510. The hot conduit 120 is arranged in fluid communication with the valve arrangement 500 via a conduit connecting to the first connection point A. The inlet 611 of the heat exchanger 600 is arranged in fluid communication with the valve arrangement 500 via a conduit connecting to the second connection point B. The cold conduit 140 is arranged in fluid communication with the valve arrangement 500 via a conduit connecting to the third connection point C. The outlet 612 of the heat exchanger 600 is arranged in fluid communication with the valve arrangement 500 via a conduit connecting to the fourth connection point D. Thereby, depending on how the four valves 510 are set, the flow between the heat exchanger 600 and the hot and cold conduits 120, 140 respectively may be controlled.

[0057] The valve arrangement 500 may be controlled by a controller 800. The controller 800 is connected to the valve arrangement 500 to selectively allow a setting of the valves 510 to thereby control the flow through the valve arrangement 500 depending on which operation mode of the thermal energy balancing device is desired, i.e. if a heat exhale mode is desired or if a heat inhale mode is desired.

[0058] In the following, the two modes of the thermal energy balancing device 400 will be exemplified with reference to Figs. 3A and 3B. The two modes differ in how the valves 510 are set and hence how the flow of heat transfer liquid is allowed to flow.

[0059] To facilitate understanding, a closed valve is illustrated by a solid black valve icon, whereas an open valve is illustrated by a solid white valve icon. Also, to facilitate understanding, Figs. 3A and 3B have been simplified by removing some components.

[0060] Starting with Fig. 3A, the heat exhale mode, is illustrated.

[0061] By closing the valves 510 between connection points B-C and A-D, while opening the valves 510 between connection points A-B and C-D, a flow of heat transfer fluid is allowed from the hot conduit 120, through the open valve 510 between connection points A-B, into the liquid phase primary side 610 of the heat exchanger

600 via its inlet 611, across the liquid phase primary side 610 of the heat exchanger 600, out of the heat exchanger 600 via its outlet 612, through the open valve 510 between the connection points D-C and into the cold conduit 140. As the hot fluid flows across the liquid phase primary side 610 of the heat exchanger 600, heat will be transferred to the gas phase secondary side 620 of the heat exchanger 600 and be exhaled. The heat may be exhaled into the ambience. Thus, during such flow, the temperature of the heat transfer fluid will be reduced. Hence, heat will be exhaled and thereby removed from the system. The exhale mode is typically run when clients connected to the thermal energy circuit 100 want a cooling effect.

[0062] Now turning to Fig. 3B, the second mode, being a heat inhale mode is illustrated. By closing the valves 510 between connection points A-B and C-D, while opening the valves 510 between connection points B-C and A-D, a flow of cold heat transfer fluid is allowed from the cold conduit 140, through the open valve 510 between connection points C-B, into the heat exchanger 610 via its inlet 611, across the liquid phase primary side 610 of the heat exchanger 600, out of the heat exchanger 600 via its outlet 612, through the open valve 510 between the connection points D-A and into the hot conduit 120. As the cold fluid flows across the liquid phase primary side 610 of the heat exchanger 600, heat will be transferred from the gas phase secondary side 620 of the heat exchanger 600 and be inhaled into the heat transfer fluid which thereby receives an increased temperature before being returned to the hot conduit 120. Thus, during such flow, the temperature of the heat transfer fluid will be increased by inhaling heat. This specific operation mode may by way of example be used during the colder period of a year in areas which have a hot climate during the major part of the year to provide heating of homes, offices, tap water etc. Thus, the inhale mode is typically run when clients connected to the thermal energy circuit 100 want a heating effect.

[0063] Now turning to Fig. 2, 3A and 3B, the thermal energy balancing device 400 may further comprise a fan 630. The fan 630 is arranged on the gas phase secondary side 620 of the heat exchanger 600. The fan 630 is configured to generate a turbulent air flow in and around the gas phase secondary side 620 to thereby enhance heat transfer between the liquid phase primary side 610 and the gas phase secondary side 620. The fan 630 is operable no matter if it is to promote a heat exhaling or a heat inhaling effect, i.e. no matter if the thermal energy balancing device 400 is set to an exhale mode or an inhale mode.

[0064] The fan 630 is configured to provide an air flow counter to the flow direction on the liquid phase primary side 610 of the heat exchanger 600. The fan 630 may be configured to provide an air flow counter to the flow direction on the liquid phase primary side 610 no matter if the thermal energy balancing device 400 is set into the heat exhale mode or into the heat inhale mode.

[0065] Now turning to Fig. 4, the thermal energy bal-

ancing device 400 may further comprise a regulator 700 and a pressure difference determining device 710. The overall design of the thermal energy balancing device 400 in Fig. 4 is the same as previously discussed in view of Figs. 2, 3A and 3B.

[0066] The pressure difference determining device 710 is configured to sense local pressure in the hot conduit 120 and the cold conduit 140 respectively and determine a difference between the two pressures. The pressure difference determining device 710 is adapted to determine a local pressure difference, Δp_{local} , between a local hot conduit pressure, p_h , of heat transfer liquid of the hot conduit 120 and a local cold conduit pressure, p_c , of heat transfer liquid of the cold conduit 140, $\Delta p_{\text{local}} = p_h - p_c$. The regulator 700 is configured to, based on the determined local pressure difference, regulate the flow of heat transfer liquid between the hot and cold conduits 120, 140.

[0067] The regulator 700 is disclosed in Fig. 2 as being arranged in a position between the hot and cold conduits 120, 140. The regulator 700 is disclosed as being arranged between the valve arrangement 500 and liquid phase primary side 610 of the heat exchanger 600. The regulator 700 may be a small frequency controlled circulation pump. The regulator 700 may be arranged either in a position before the inlet 611 to the primary side of the heat exchanger 600, or after the outlet 612 from the primary side of the heat exchanger 600. The purpose of the regulator 700 is to facilitate the flow of heat transfer liquid to the heat exchanger 600 in the event the determined pressure difference between the hot conduit 120 and the cold conduit 140 should be below a predetermined set value. As long as the determined local pressure difference is determined to be above the set value, the regulator 700 may be set into a passive mode and act as an open valve allowing a flow of heat transfer fluid to pass therethrough. Should the determined local pressure difference instead be determined to be below the set value, the regulator 700 may be set into an active mode and pump the heat transfer liquid to thereby increase the pressure of the heat transfer fluid as seen in a position downstream the regulator 700.

[0068] The regulator 700 and the pressure determining device 710 may be connected to the controller 800. The controller 800 may be the same as is used to control the valve arrangement 500.

[0069] The pressure difference determining device 710 may be embodied in many different ways as will be given below. The pressure difference determining device 710 may, as is illustrated in Fig. 4, be integrated in the regulator 700. One example of such integrated regulator 700 and pressure difference determining device 710 is a differential pressure regulator.

[0070] If the detected pressure in a position adjacent an inlet end 700a of the regulator 700 should be determined to be lower than a predetermined set value, the regulator 700 is activated. Thereby, the pressure at the outlet end 700b of the regulator 700, and hence the pres-

sure of the heat transfer liquid supplied from a first conduit to a second fluid in the thermal energy circuit 100 will be increased. Thereby a detected local pressure difference between the hot conduit 120 and the cold conduit 140 may be adjusted. In the event of a heat exhale mode, the first conduit will be the hot conduit 120 and the second conduit will be the cold conduit 140. Correspondingly, in the event of a heat inhale mode, the first conduit will be the cold conduit 140 and the second conduit will be the hot conduit 120.

[0071] Should the detected pressure difference be determined to be allowable, the regulator 700 will instead be set in a passive mode and allow a bypass of heat transfer liquid.

[0072] In another embodiment, see Fig. 5 the pressure difference determining device 710 may be arranged as an independent device separate from the regulator 700. In this embodiment, the pressure difference determining device 710 comprises a hot conduit pressure determining unit 710a which is connected to the hot conduit 120 for measuring the hot conduit local pressure, p_h . Further, the pressure difference determining device 710 comprises a cold conduit pressure determining unit 710b which is connected to the cold conduit 140 for measuring the cold conduit local pressure, p_c . The local pressure difference, Δp_{local} , is then determined as $\Delta p_{\text{local}} = p_h - p_c$. If the determined local pressure difference is determined to be below a predetermined set value, the regulator 700 is activated. Thereby, the pressure at the outlet end 700b of the regulator 700, and hence the pressure of the heat transfer liquid supplied from a first conduit to a second fluid will be increased. In the event of a heat exhale mode, the first conduit will be the hot conduit 120 and the second conduit will be the cold conduit 140. Correspondingly, in the event of a heat inhale mode, the first conduit will be the cold conduit 140 and the second conduit will be the hot conduit 120. Thereby a detected local pressure difference between the hot conduit 120 and the cold conduit 140 may be adjusted to be within a pre-determined set pressure difference.

[0073] Should the detected pressure difference be determined to be allowable, the regulator 700 will instead be set in a passive mode and allow a bypass of heat transfer liquid.

[0074] The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

[0075] The valve arrangement 500 has been described as comprising four valves 510 which are interconnected in a closed loop with one connection point A to the hot conduit 120, one connection point C to the cold conduit 140, one connection point B to the inlet 611 of the liquid phase primary side 610 of the heat exchanger 600 and one connection point D to the outlet 612 of the liquid phase primary side 610 of the heat exchanger 600. The skilled person realizes that the number of valves 510 and

their mutual interconnection and their connection with the heat exchanger 600 and the hot and cold conduits 120, 140 may be varied with remained function.

[0076] The regulator has been disclosed as being arranged between the valve arrangement 500 and the liquid phase primary side 610 of the heat exchanger. The skilled person understands that other positions are possible.

[0077] Also, the skilled person realizes that a local pressure difference may be determined in a number of ways within the scope of the claims.

[0078] Additionally, variations to the disclosed embodiments can be understood and effected by the skilled person in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

Claims

1. A thermal energy balancing device (400) connected to a thermal energy circuit (100) comprising a hot conduit (120) configured to allow heat transfer liquid of a first temperature to flow therethrough, and a cold conduit (140) configured to allow heat transfer liquid of a second temperature to flow therethrough, the second temperature being lower than the first temperature, the thermal energy balancing device (400) comprising:
 - a liquid-to-air heat exchanger (600) comprising a liquid phase primary side (610) and a gas phase secondary side (620); and
 - a valve arrangement (500) configured to selectively set the thermal energy balancing device (400) into
 - a heat exhale mode wherein heat transfer liquid is directed to flow from the hot conduit (120) via the primary side (610) of the heat exchanger (600) to the cold conduit (140), and into
 - a heat inhale mode wherein heat transfer liquid is directed to flow from the cold conduit (140) via the primary side (610) of the heat exchanger (600) to the hot conduit (120).
2. The thermal energy balancing device according to claim 1, wherein the liquid phase primary side (610) comprises an inlet (611) and an outlet (612), and wherein the valve arrangement (500) is configured to direct a flow of heat transfer liquid from the inlet (611) to the outlet (612) when the valve arrangement (500) is set into the heat exhale mode and when the valve arrangement (500) is set into the heat inhale mode.
3. The thermal energy balancing device according to claim 1 or 2, further comprising a fan (630) configured to produce an air flow at the gas phase secondary side (620) of the liquid-to-air heat exchanger (600).

4. The thermal energy balancing device according to claim 3, wherein the fan (630) is configured to provide an air flow counter to the flow direction on the primary liquid side (610) of the liquid-to-air heat exchanger (600). 5

5. The thermal energy balancing device according to claim 3, wherein the fan (630) is configured to provide an air flow counter to the flow direction on the primary liquid side (610) of the liquid-to-air heat exchanger (600) no matter if the thermal energy balancing device (400) is set into the heat exhale mode or into the heat inhale mode. 10

6. The thermal energy balancing device according to any of the preceding claims further comprising a regulator (700) and a pressure difference determining device (710) adapted to determine a local pressure difference, Δp_{local} , between a local hot conduit pressure, p_h , of heat transfer liquid of the hot conduit (120) and a local cold conduit pressure, p_c , of heat transfer liquid of the cold conduit (140), $\Delta p_{\text{local}} = p_h - p_c$; and 15
 wherein the regulator (700) is configured to, based on the determined local pressure difference, regulate the flow of heat transfer liquid between the hot and cold conduits (120; 140). 20
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7. The thermal energy balancing device according to any of the preceding claims, further comprising a controller (800) connected to one or more of the pressure difference determining device (710), the regulator (700) and the valve arrangement (500). 30
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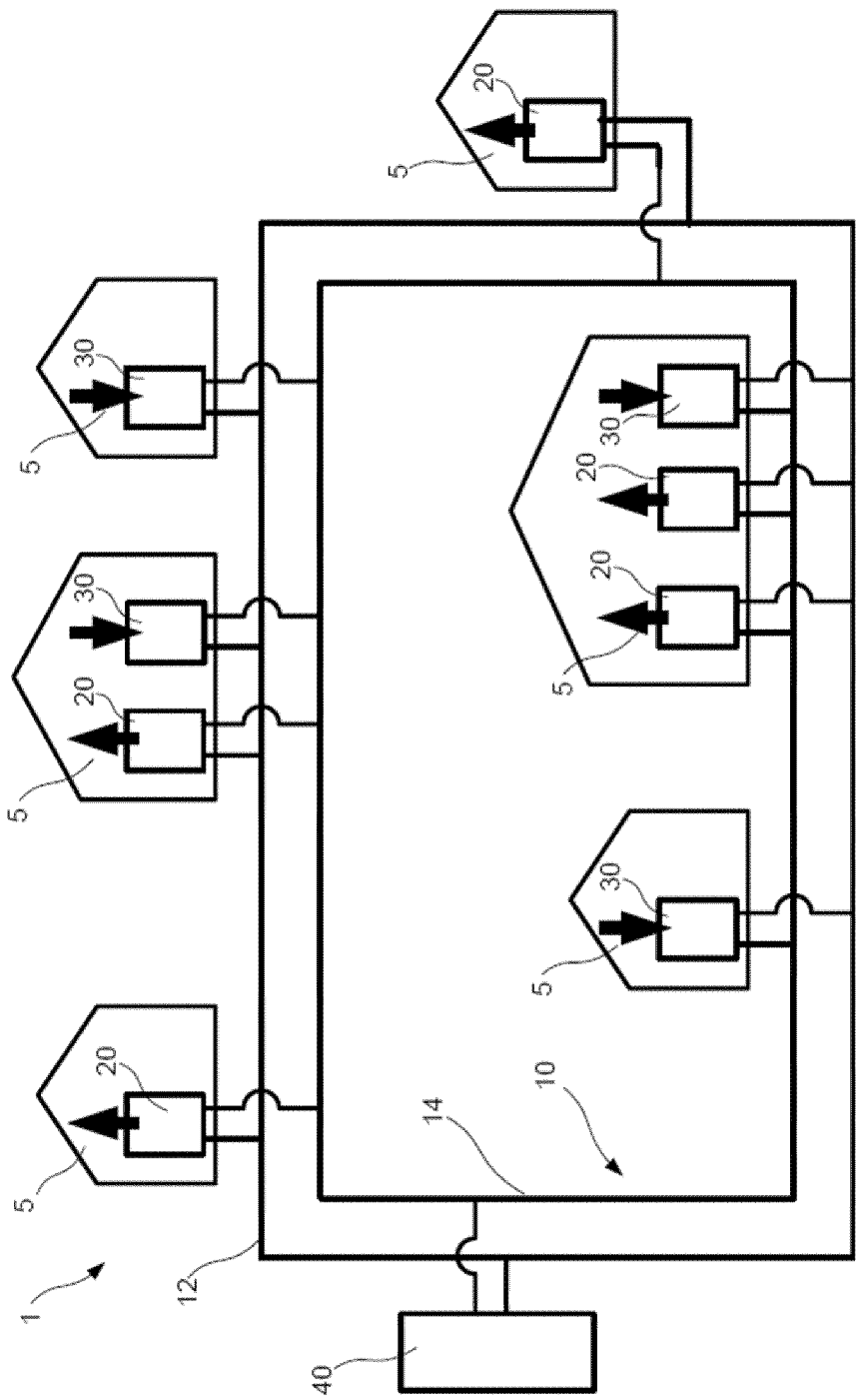


FIG. 1

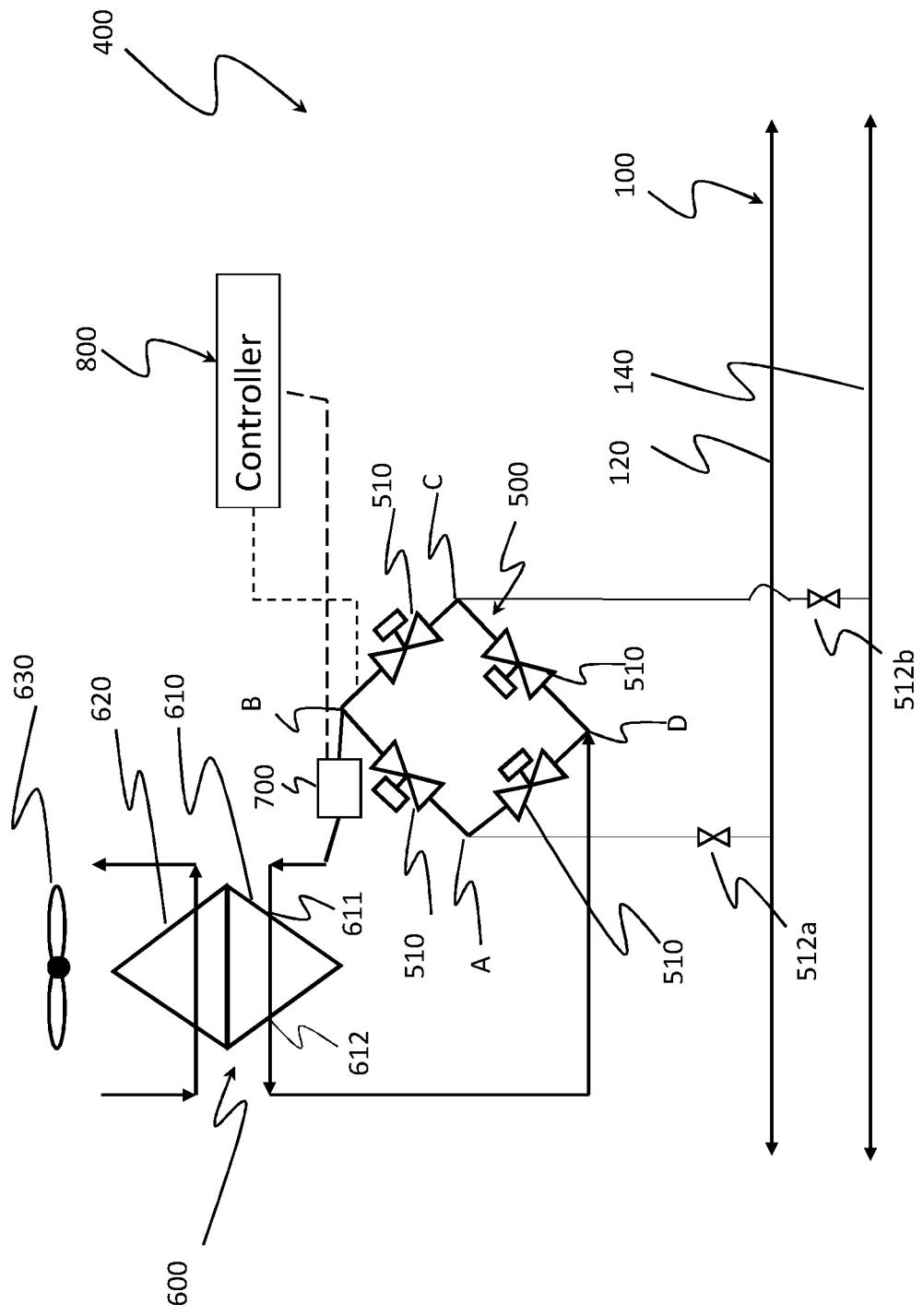


Fig. 2

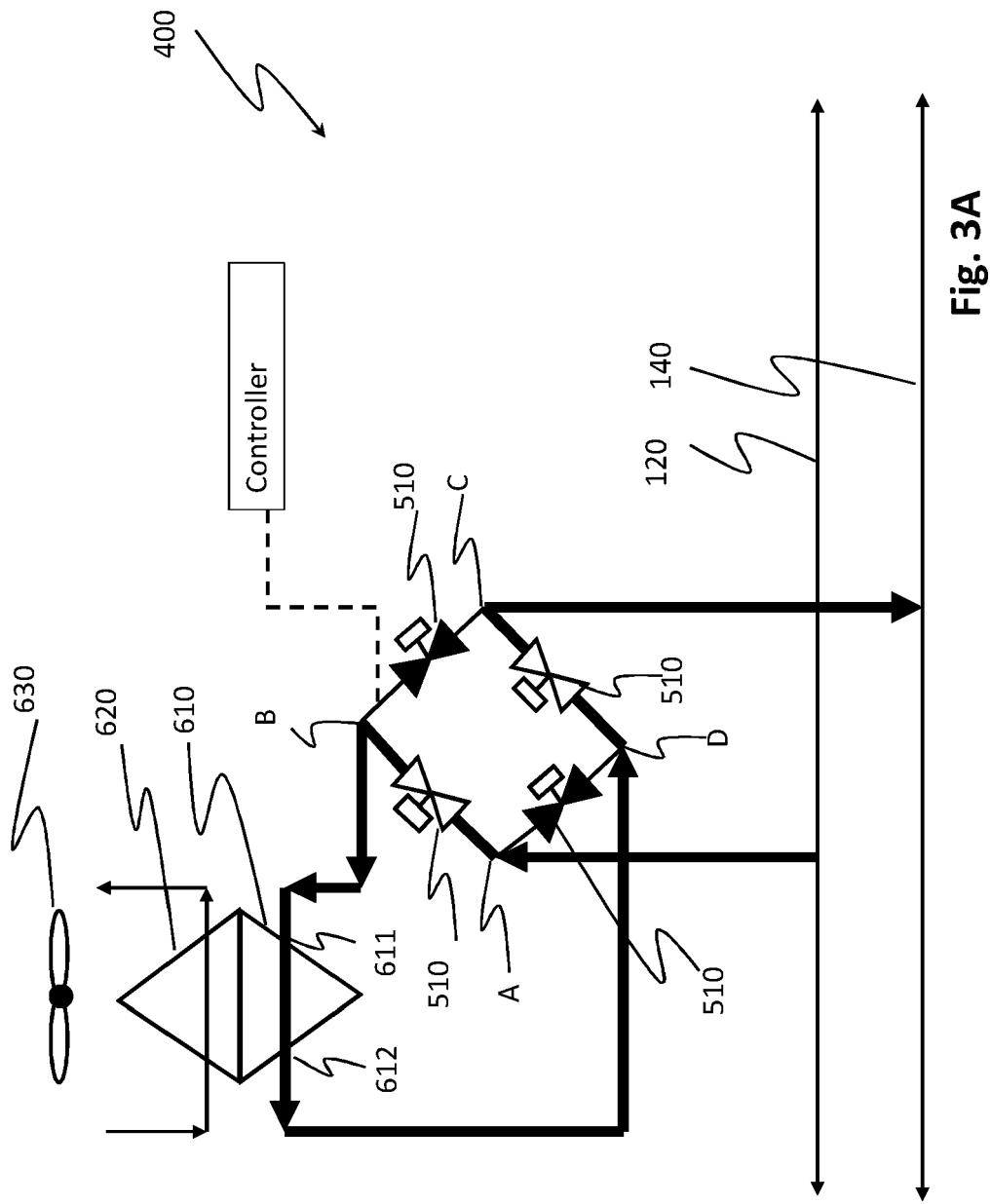


Fig. 3A

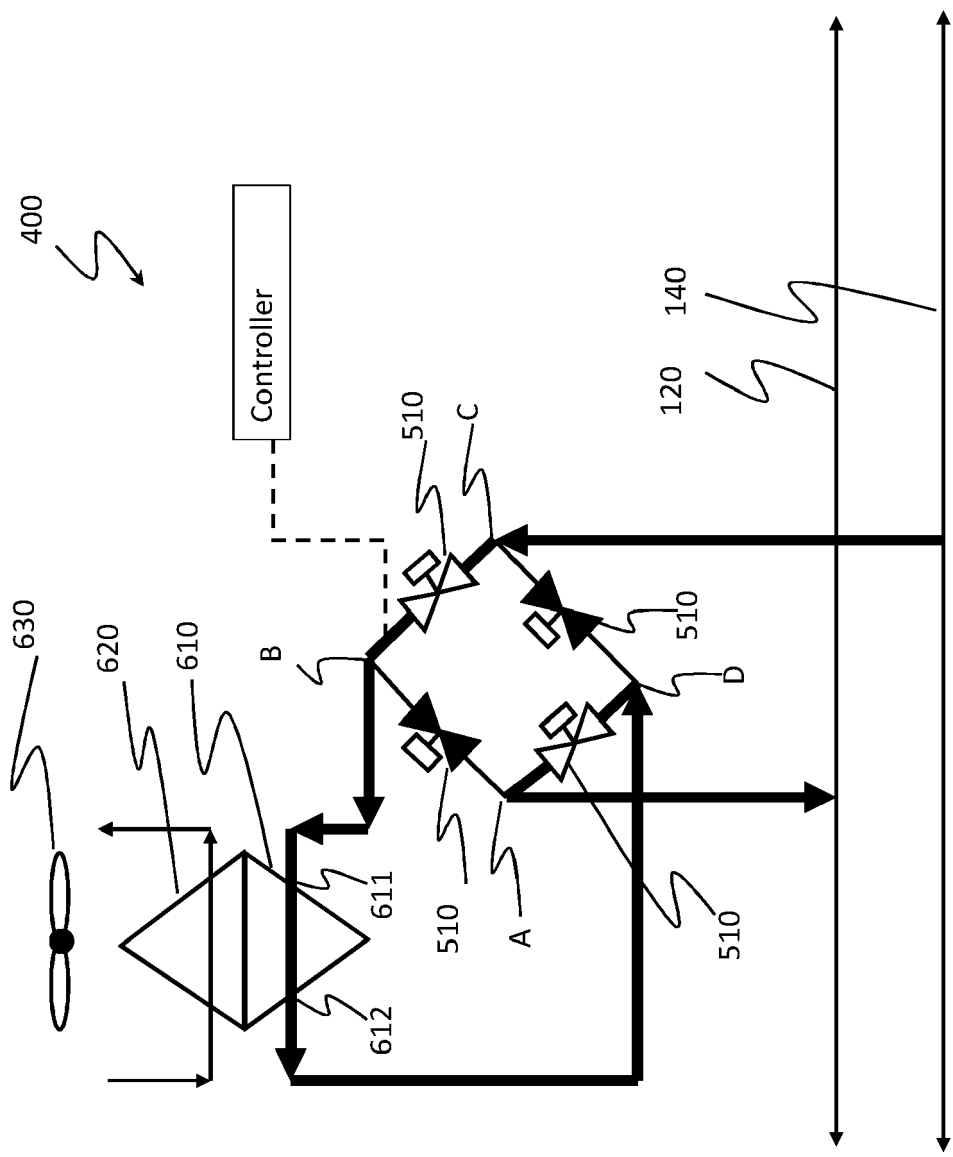


Fig. 3B

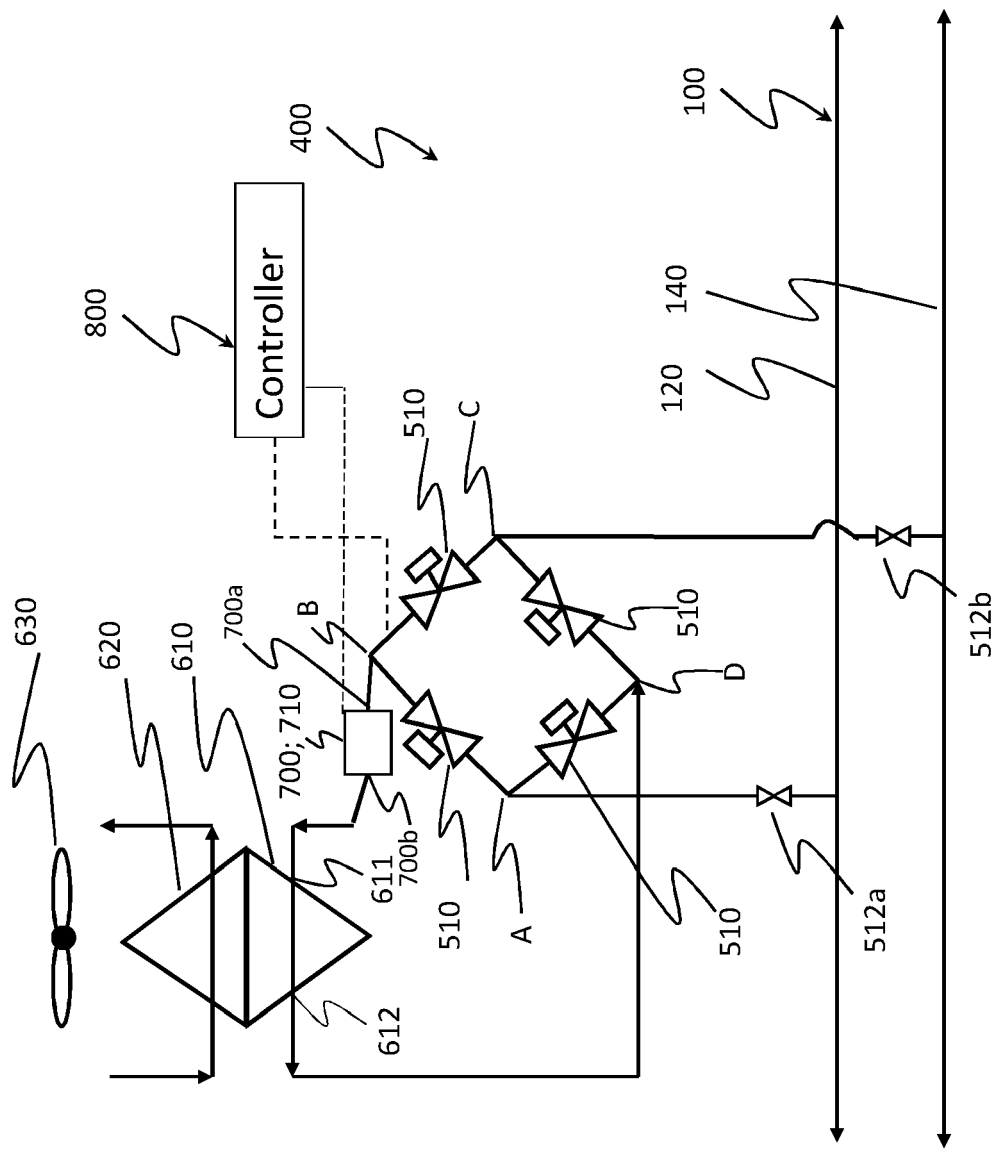


Fig. 4

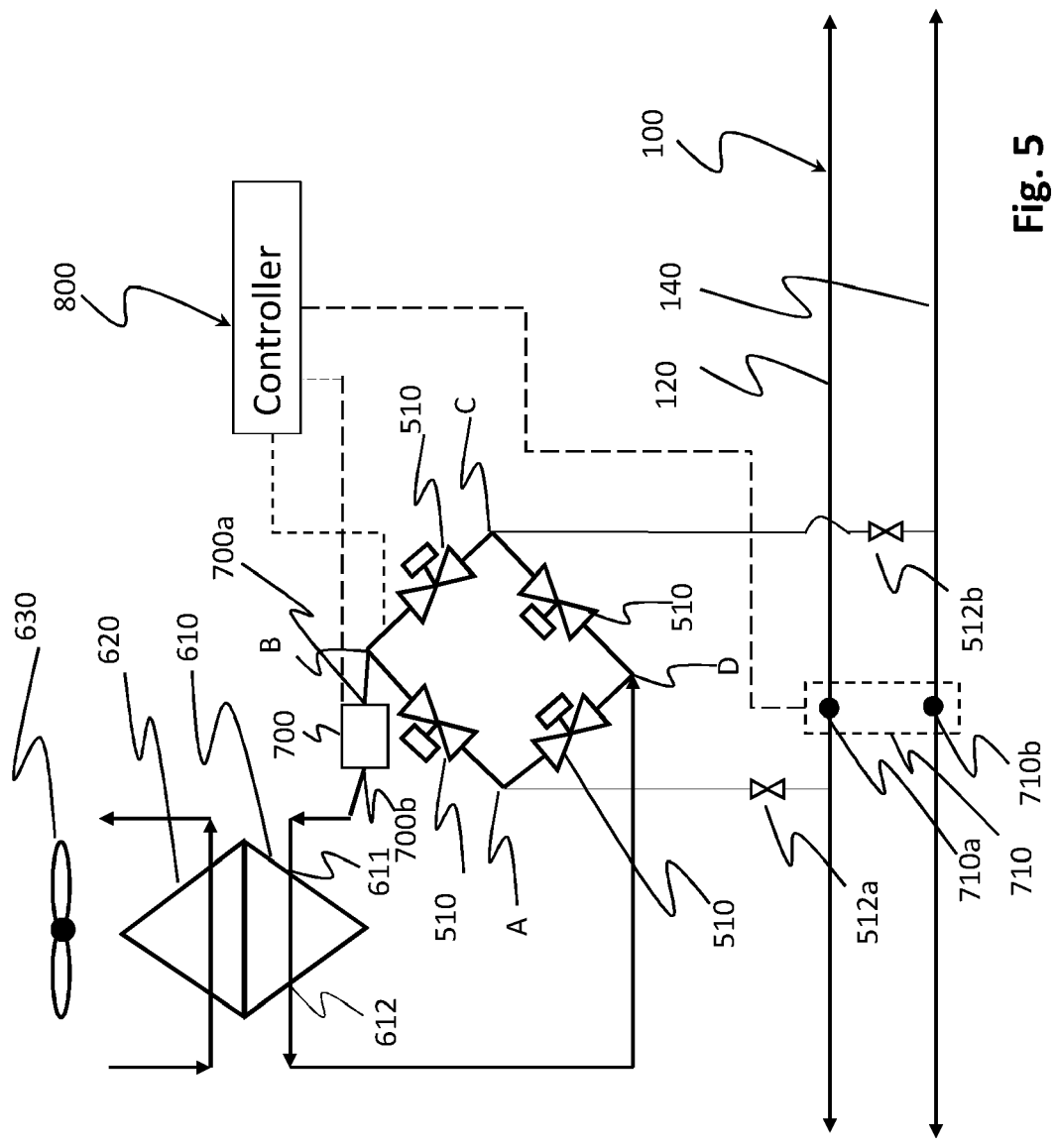


Fig. 5



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Place of search Munich		Date of completion of the search 14 May 2021	Examiner Riesen, Jörg
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