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(54) **A HEATING AND/OR COOLING SYSTEM FOR COLLECTIVE RESIDENTIAL HOUSING UNITS, A CONTROL DEVICE THEREFOR AND A METHOD FOR THE CONTROL THEREOF**

(57) A heating and cooling system for collective residential housing units. The system includes: a collective heat pump, a plurality of residential housing units, one closed circuit for circulating a liquid between the collective heat pump and the residential housing units, and a control device for controlling the collective heat pump. The control device controls the temperature of the collective water pump and/or the maximum flow rate from the closed circuit to each of the housing units and/or the flow rate over a bypass on the closed circuit in function of the current needs of the residential housing units.

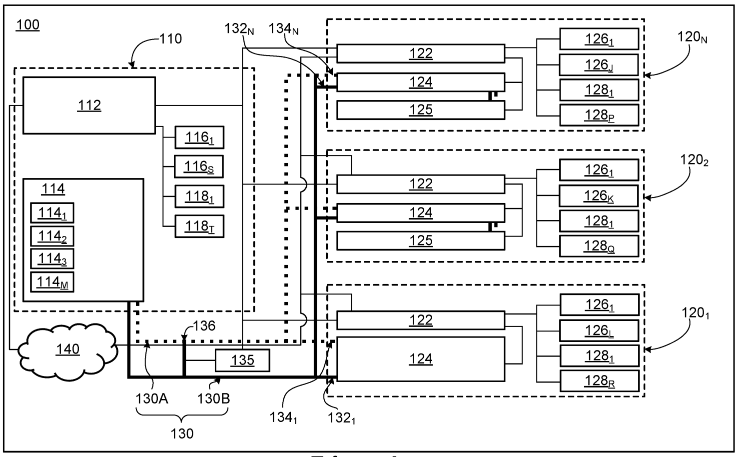

Fig. 1

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Description

Technical field

[0001] The present invention relates to a control device for a heating and/or cooling system for collective residential housing units. The present invention also relates to a heating and/or cooling system for collective residential housing units comprising such a control device. The present invention also relates to a method for controlling a heating and/or cooling system for collective residential housing units.

State of the art

[0002] Heating and/or cooling systems for collective residential housing units are known. Classic examples are a central heating in an apartment building, a heating network (or cooling network) in a residential neighbourhood. In general, these systems comprise one or more sources of thermal energy that is distributed by means of a medium (e.g. steam, hot liquid or cold liquid) from a central location to multiple locations for heating and/or cooling of spaces and /or processes. There are many known sources of thermal energy, such as the combustion of fossil fuels (e.g. a central heating boiler), the use of electricity to generate heat (e.g. an electric heater), or by means of a heat pump (e.g. a air-water heat pump). A heat pump is also often used in combination or as part of a BEO (Borehole Energy Storage) field or a KWO (Cold Heat Storage) field.

[0003] The present invention specifically relates to systems that use a collective heat pump to provide thermal energy to a collection of residential housing units. This collection may consist of several apartments in one or more apartment buildings and/or several separate residential buildings. Each of the residential housing units has its own separate heating and/or cooling system. Many such systems are known, such as classic radiators, underfloor heating, underfloor cooling, convectors, etc. Which system is used locally is of secondary importance in the context of the present invention.

[0004] In a classic setup, typically, two separate loops between the collective heat pump and the residential housing units, are used, namely a first loop for the circulation of a warm medium and a second loop for the circulation of a cold medium. The medium is typically a liquid, such as water, but other media are possible. Each housing unit is connected to both loops and can draw both heat and cold depending on the needs. The use of two loops allows to meet the possibly different needs of the individual housing units. In particular, there are often situations wherein a number of housing units require heating, while another group of housing units does not require heating or even cooling. Examples are: a sunny spring day wherein south-facing housing units heat up sufficiently, due to the incident sunlight, but north-facing housing units do not; or the circumstance that certain housing units are not occupied during the day (e.g. the residents are at work) and therefore require less or no thermal energy, while this is not the case for other housing units; etc. Examples of such two-loop systems are described in EP 3 165 831, EP 3 184 914 and EP 3 372 903.

[0005] The main disadvantage of such systems is the need to install two completely separate loops. First of all, this requires a lot of raw materials (both in conduit material and in insulation), as well as more time for the installation thereof. In addition, due to the doubling, there is approximately twice as much chance that a leak or other defect will occur somewhere. Many more couplings, taps, sensors, etc. are also required.

[0006] There are also known systems that work on a single loop basis, for example as disclosed in US 10,641,510. There, a system for controlling a collective heating of a district has been disclosed. The system obtains information from the various actors involved (i.e. energy sources and energy sinks). The purpose of the disclosure in US 10,641,510 is to determine whether it is more advantageous, depending on the energy needs, to use either a ground heat exchanger or a ground source heat pump.

[0007] If the system is set up only for heating or only for cooling, there is typically only one loop present in which respectively a hot or cold medium circulates. A known problem when circulating a medium, in particular a liquid, in a loop is related to pressure differences. On the one hand, pressure differences arise as a result of pressure loss as a result of the transport over the loop. On the other hand (and/or incidentally), height differences over the loop can also play a role. In general: the further a housing unit on the loop, the lower the incoming pressure. These pressure differences in turn give rise to differences in flow rate per residential housing unit, which flow rate is directly related to the maximum energy transfer to the housing unit. As an illustration, in an apartment building with 10 different apartments, this can lead to insufficient heating or cooling at the apartment furthest away from the thermal energy source.

[0008] In practice, such problems are solved by manually adjusting the maximum flow rate available for each housing unit. In concrete terms, a flow rate limiter is provided on each supply branch from the loop to a housing unit. A technician controls each of these limiters in such a way that each housing unit can receive the same (or the necessary) flow rate to meet the theoretical maximum energy requirements.

[0009] A disadvantage to this solution is the time required to have a technician carry out this adjustment. In addition, this is also a static solution that cannot take into account any changes later. Examples of such changes are: a change in local heating or cooling in a housing unit that requires more or less flow rate or a defect in the thermal energy source resulting in an insufficient flow rate. In addition, in a combined heating and cooling system, control of the limiters is also required on the branch with both loops, which further increases the workload for the technician.

[0010] Furthermore, in the context of a collective heat pump, in particular an air-to-water heat pump, there are also operational requirements. In particular, conditions on the flow rate through the heat pump and specifically the requirement that a predetermined minimum flow rate is necessary for operation must be taken into account. However, in certain situations, for example if a significant number of housing units shuts off (or drastically limits) their supply, there is a risk that the flow rate through the heat pump is too low and in particular lower than the predetermined minimum flow rate. In such a case, the heat pump stops automatically and there is no longer any option for heating and/or cooling.

[0011] A known solution is to provide a bypass in the loop that bypasses the housing units with a lockable valve on top. Opening this valve increases the flow rate in the loop such that it remains higher than the predetermined minimum flow rate. However, the inventors have determined that this solution can be disadvantageous. For example, it is possible that due to the flow rate over the bypass, there is insufficient flow available for the necessary energy transfer to the housing units.

Description of the invention

[0012] The aim of the present invention is to reduce and/or remedy one or more of the disadvantages described above. This aim is achieved according to the invention as set out in the claims.

[0013] In a first aspect, the present disclosure concerns a control device for controlling a collective heat pump in a heating and cooling system for collective residential housing units, which heating and cooling system is provided with: the collective heat pump, a plurality of residential housing units, and one closed circuit for circulating a liquid between the collective heat pump and the residential housing units, wherein the control device is provided with: an interface configured to obtain actual temperature data and desired temperature data from each residential housing unit; a decision module configured to determine, on the basis of the actual temperature data and the desired temperature data, a desired temperature of said liquid on an output side of the collective heat pump; and a control module configured to generate, based on said desired temperature control, signals for controlling the collective heat pump.

[0014] In this aspect, the disclosure provides a control device that allows to provide both heating and cooling by using a collective heat pump and this with only one closed circuit for circulating the liquid between the collective heat pump and the residential housing units. By the interface that obtains actual and desired temperature data, the control device, in particular the decision module, is able to determine the general need of the collective residential housing units, i.e. is there a global need for heating or cooling. The control device then determines the desired temperature of said liquid on an output side of the collective heat pump depending on the specific general need, e.g. a relatively warm liquid (e.g. 35 °C or 45 °C) for heating or a relatively cold liquid (e.g. 10 °C) for cooling. Based on the desired temperature, the control device then generates the necessary control signals. The same closed circuit can therefore serve for both heating and cooling for the residential housing units.

[0015] In a first embodiment of the disclosure, the control device is further provided with: a database configured to store the actual temperature data and the desired temperature data (preferably this is data which represents the desired temperature during a future time interval), which database further contains energy loss data (the energy loss data is e.g. an indication of the temperature evolution in a residential housing unit in time in the absence of energy inflow) of each residential housing unit; and an analysis module configured to determine, based on the actual temperature data, the desired temperature data and the energy loss data, energy requirement data for each residential housing unit, wherein the decision module is configured to generate, based on the energy requirement data, a temperature-time profile of the desired temperature of said liquid on the output side of the collective heat pump as a function of time during a future time interval.

[0016] The use of energy loss data in combination with the temperature data (both actual and desired) allows to calculate an estimate of the energy that will be required by each housing unit during a future time interval (e.g. for the next hour or the next two or three hours). Such an estimate may comprise, for example, that a first group of housing units requires additional energy to heat the housing unit for 1 hour and then requires energy to compensate for their energy loss, while a second group of housing units only requires energy to compensate for their energy loss, and a third group of housing units just wants to emit energy to cool the housing unit for two hours. Based on this estimate, the decision module generates a temperature-time profile of the liquid on the output side of the collective heat pump to meet the different needs. This first embodiment of the disclosure therefore provides control (or regulation) during a future time interval.

[0017] It may also be advantageous to, during generating the temperature-time profile, also take into account properties, such as the efficiency, of the different local heating and cooling systems present in the different residential housing units. Certain types of heating and cooling systems require more/less energy to go from the actual temperature to the desired temperature.

[0018] In a preferred embodiment of the disclosure, the control device is further provided with a communication module configured to send the calculated temperature-time profile to each residential housing unit. In this way, each housing unit is aware of the temperature of the liquid in the closed circuit during the future time interval. The housing units (in particular the control device provided therein) can then control the local heating and cooling system based on the temperature of the incoming liquid. In the example described above this allows the local control devices of the housing units of the first group to take energy in the time period where relatively warm liquid arrives, while the local control devices of the housing units of the third group to not take any energy, f.e. by closing a supply tam, in this time period.

[0019] In a preferred embodiment of the disclosure, the database further comprises historical data of each residential housing unit, which historical data at least comprises data about: the desired temperature, the actual temperature, and energy consumption data, which historical data preferably comprises data about: the season, the weather conditions, and/or an occupancy in the residential housing unit, whereby said energy loss data has been obtained on the basis of the historical data stored in the database. More preferably, the control device is further provided with a machine learning module, trained on the historical data and configured to generate said energy loss data. Firstly, it is possible to search the historical data set to find an identical (or similar) set of conditions and thus find accurate energy loss data for the actual situation. However, because energy loss is the result of a plurality of different factors, it is preferable to use machine learning techniques (e.g. a neural network), trained on the historical data, to predict the energy loss data for the actual situation.

[0020] In a second embodiment of the disclosure, the control device is further provided with an analysis module configured to determine a temperature difference value between the actual temperature data and the desired temperature data, wherein the decision module is configured to determine said desired temperature on the basis of the temperature difference value.

[0021] The main advantage of this second embodiment of the disclosure is that there is no need to determine energy loss data for each residential housing unit. The control is carried out on the basis of the actual and desired temperature data, which allows, e.g. via the temperature difference value, to determine a actual global demand/need in the whole of the collective housing units. The desired temperature is then determined based on the global demand.

[0022] In a preferred embodiment of the disclosure, the analysis module is further configured to determine whether the collective heat pump, in a predetermined elapsed time interval, has been changed between a heating mode and a cooling mode, and wherein the decision module is configured, if the mode of the collective heat pump has been changed in said predetermined elapsed time interval, to determine said desired temperature such that no mode change occurs. Changing the mode of the collective heat pump costs a lot of energy, because the temperature on the output side has to change drastically, namely from heating (e.g. 35 °C) to cooling (e.g. 10 °C) or vice versa. It is therefore not desirable to frequently undergo such a mode change. A check to determine whether or not a mode change has occurred in a predetermined time interval (e.g. the past two hours) prevents too frequent changing.

[0023] In an embodiment of the disclosure, the control device is further provided with a machine learning module, trained on historical desired temperature data of a residential housing unit and configured to generate said desired temperature data. This avoids the need for a user (e.g. a resident of the housing unit) to manually enter a schedule or manually provide desired temperature data.

[0024] The advantages of the embodiments of the disclosure described above and/or the first aspect of the disclosure are also achieved with a heating and cooling system for collective residential housing units, which heating and cooling system is provided with: a collective heat pump, a plurality of residential housing units, each provided with a heating and cooling system and a local control device for controlling it, one closed circuit for circulating a liquid between the collective heat pump and the heating and cooling systems of the housing units, a central control device, as described above, for controlling the collective heat pump.

[0025] In an embodiment of the disclosure, the collective heat pump comprises a plurality of air-water (generally air-liquid) heat pumps and/or water-water (generally liquid-liquid) heat pumps, in particular a monoblock heat pump, which are preferably arranged in parallel. Air-water heat pumps have many advantages, for example, they can be placed and used anywhere without additional systems (such as a BEO field). The use of multiple air-water heat pumps also provides the necessary redundancy, e.g. if one heat pump is defective, this can be absorbed by the remaining ones. Placing the heat pumps in parallel is further advantageous because one or more of the heat pumps can easily be switched on or off depending on the actual needs. A defective heat pump can also easily be accommodated by the remaining one and can be repaired or replaced without impact on the rest of the system. Finally, the use of a monoblock heat pump increases the safety and reduces the cost price. The refrigerant (or heating agent) is only present in one component, which is completely separated from the liquid in the closed loop, in which for example water can circulate. The installation of the system can therefore largely be done without the intervention of a specialized technician.

[0026] The use of water-to-water heat pumps, on the other hand, is advantageous in applications with geothermal energy, e.g. a BEO (Borehole Energy Storage) field or a KWO (Cold Heat Storage) field. Such geothermal applications require the use of a liquid-liquid heat pump. A common installation includes a single water-to-water heat pump between the BEO/KWO field and the residential housing units. The water-water heat pump has a high power (e.g. more than 100 kW) and only has an ON mode and an OFF mode. As a result, there is a need for a system of redundancies (e.g. expansion tanks, pressure vessels, spare vessels, etc.) to meet variable energy needs. Furthermore, frequency-controlled water-to-water heat pumps are also known that allow to meet a variable energy requirement via the variable frequency (i.e. a heat pump with a constant flow but a variable frequency to vary a difference in temperature between the incoming and outgoing liquid). However, its cost is not economically viable for use in collective residential housing units compared to the system of redundancies. In addition, this often creates situations in which the heat pump does not operate in optimal conditions.

[0027] The disclosure makes allows to replace one high-power heat pump with several low-power heat pumps (e.g. a power of about 5-20 kW, such as 10 kW). Furthermore, the redundancies are unnecessary in the context of the disclosure since the variable energy needs can be met by temporarily switching on or off certain heat pumps. In addition, multiple frequency-controlled water-to-water heat pumps can also be used that in this way, in addition to switching a heat pump on or off, respond even better to the variable energy need.

[0028] The use of both air-water (general air-liquid) and water-water (general liquid-liquid) heat pumps in the same system allows to make optimal use of them in dependence on weather conditions. To illustrate, the efficiency of an air-to-water heat pump for heating decreases with a decreasing outside temperature. A BEO/KWO field each have a maximum total energy capacity that must remain constant overall over one year. This is typically achieved by injecting the energy extracted in the winter for heating back into the field by cooling in the summer. For example, if the outside temperature is above 10°C, an air-to-water heat pump is sufficiently efficient so that these heat pump(s) can provide the system with the necessary energy and therefore no energy has to be extracted from the BEO/KWO field. At a lower temperature, it is then possible to switch to the water-to-water heat pump(s) that are more efficient than the air-to-air heat pumps at such temperatures. In the summer, if necessary, the air-to-water heat pump can be used as an additional source to inject energy into the BEO/KWO field by means of the water-water heat pump(s). This additional injection of energy into the BEO/KWO field by means of the air-to-water heat pumps in the summer can be advantageous for various reasons, e.g. as compensation for excess/exceptional use in the past winter or in a relatively cool summer where there is only little cooling, etc. and therefore generally serves to maintain the overall energy balance of the BEO/KWO field over the period of one year.

[0029] The advantages of the embodiments of the disclosure described above and/or the first aspect are also achieved with a method for controlling a collective heat pump in a heating and cooling system for collective residential housing units (in particular the heating and cooling system, as described above), which method comprises the following steps: obtaining actual temperature data and desired temperature data from each residential housing unit; determining a desired temperature of a liquid on an output side of a collective heat pump based on the data obtained; and generating control signals for controlling the collective heat pump to achieve the desired temperature.

[0030] In a first embodiment of the disclosure, determining the desired temperature comprises: obtaining energy loss data for each residential housing unit; and, based on the energy loss data, generating a temperature-time profile of the desired temperature of said liquid on the output side of the collective heat pump as a function of time during a future time interval. Preferably, obtaining energy loss data comprises machine learning thereof by means of training on historical data of each residential housing unit, which historical data comprises at least data regarding: the desired temperature, the actual temperature, and energy consumption data, which historical data preferably comprises data about: the season, the weather conditions, and/or an occupancy in the residential housing unit. In this embodiment of the disclosure the method preferably further comprises sending the calculated temperature-time profile to each residential housing unit. The advantages of using energy loss data in determining a temperature-time profile have already been described above.

[0031] In a second embodiment of the disclosure, determining the desired temperature comprises: determining a temperature difference value between the actual temperature data and the desired temperature data; and determining whether the collective heat pump was changed between a heating mode and a cooling mode in a predetermined elapsed time interval. The advantages of using the temperature difference value have already been described above.

[0032] In a second aspect, the present disclosure concerns a control device for controlling a heating and/or cooling system for collective residential housing units, which heating and cooling system is provided with: a collective heat pump, a plurality of residential housing units, one closed circuit for circulating a liquid between the collective heat pump and the residential housing units, and for each residential housing unit, a supply branch from the closed circuit to the residential housing unit, each supply branch being provided with an adjustable valve for regulating a flow rate at the supply branch, wherein the control device is provided with: an interface configured to obtain a actual flow rate in the closed circuit and maximum flow rate data of each supply branch, which maximum flow rate data are based on an energy requirement of the corresponding housing unit; a decision module configured to determine, based on the data obtained, a maximum flow rate for each residential housing unit; and a communications module configured to send maximum flow rate rat data to a respective residential housing unit.

[0033] In this aspect, the disclosure provides a control device that allows automatic flow rate control. More specifically, by knowing the data regarding the maximum required flow rat and the actual flow rate in the closed circuit (e.g. on the output side of the collective heat pump), the control device can accurately distribute the actual flow rate to each of the housing units without the need for a technician who will come to arrange everything manually. In addition, the control device can also adjust the permitted flow rate per housing unit depending on the available flow rate in the closed circuit, which is advantageous, especially in situations wherein the collective heat pump is not able to deliver a sufficiently high flow rate (e.g. in extreme weather conditions or a defect). In this way, a situation is avoided wherein one or more housing units connected at the end of the closed circuit (or more generally connected at an area in the closed circuit with low pressure) have too little flow rate.

[0034] In an embodiment of the disclosure, the decision module is configured to: determine the total maximum flow rate by taking the sum of all maximum flow rate data; if the total maximum flow rate is smaller than the actual flow rate, to determine the maximum flow rate of each residential housing unit as its maximum flow rate data; and if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate. The decision module therefore checks whether the actual flow rate in the closed circuit is greater or smaller than the sum of the theoretical maximum flow rate that may be required by each housing unit. If this is the case, then each housing unit can consume its maximum flow rate. However, if this is not the case, then the maximum flow rate is fractionally limited everywhere such that each housing unit receives at least part of the flow rate.

[0035] In an embodiment of the disclosure, the communications module is further configured to receive data from the residential housing units, and wherein, upon receipt of an activation signal from one of the residential housing units, which activation signal comprises a request for a greater flow rate than the maximum flow rate data of said one of the residential housing units, the decision module is configured to: determine the total maximum flow rate by taking the sum of all maximum flow rate data for all residential housing units except said one of the residential housing units with the aforementioned larger flow rate; if the total maximum flow rate is less than the actual flow rate, to determine the maximum flow rate of each residential housing unit as its maximum flow rate data for all residential housing units except said one of the residential housing units; and to determine the maximum flow rate of said one of the residential housing units as said larger flow rate; and if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate. In the event that one housing unit requires a greater flow than its theoretical upper limit (e.g. after prolonged nonoccupation), this embodiment of the disclosure allows to check whether there is a flow rate surplus on the closed circuit. If there is such a surplus, the maximum flow rate of the one residential housing unit will be further increased.

[0036] In an embodiment of the disclosure, the control device is configured to control a heating and cooling system for collective residential housing units. As already described, one joint system has advantages over two separate systems, namely one for heating and one for cooling.

[0037] In a preferred embodiment of the disclosure, the interface is further configured to obtain actual temperature data and desired temperature data from each residential housing unit and temperature data from the liquid on an output side of the collective heat pump, wherein the control device is further provided with an analysis module configured to: based on the actual temperature data and the desired temperature data, to determine a status of each housing unit, wherein the status is one of the following: heating and cooling, and to determine a status of collective heat pump, based on the temperature data of the liquid on the output side of the collective heat pump, wherein the status is one of the following: heating and cooling, wherein the decision module is configured to exclude, based on the status data, any residential housing unit that has a different status than the collective heat pump from determining the maximum flow rate. Preferably, the decision module is configured to: determine the total maximum flow rate by taking the sum of all maximum flow rate data for the non-excluded residential housing units; if the total maximum flow rate is less than the actual flow rate, to determine the maximum flow rate of each non-excluded residential housing unit as its maximum flow rate data; and if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each non-excluded residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate. Since the energy requirements (and therefore the maximum flow rates) of a housing unit are typically different for heating and cooling, it is advantageous, before calculating the maximum flow rates, to first check which housing units have the same status as the collective heat pump. Housing units with a different status typically draw no or very little flow rate from the closed circuit, as there is no need for hot water from the closed circuit if the housing unit is in cooling status. It is therefore better not to take housing units with a different status than the collective heat pump into account when determining the maximum flow rates.

[0038] The flow rate from the closed circuit to a housing unit is a reflection of the amount of water (generally working fluid) that flows to the housing unit in a certain time interval (f.e. 1 hour). This water has a certain temperature as determined by the collective heat pump. This water is a source of energy that is available for the local heating and cooling system of the housing unit for heating or cooling. In other words, if the actual or maximal energy requirement of the housing unit is known, this can be converted into a specific amount of water needed in a specific time frame, i.e. an actual or a maximal flow rate.

[0039] In an embodiment of the disclosure, if the total maximum flow rate is greater than the actual flow rate, the decision module is configured to increase the flow rate in the closed loop. This is an alternative solution for providing a sufficient flow in each housing unit, which avoids the need to fractionally limit the maximum flow rate. However, this solution is not always applicable as not every collective heat pump can deliver a variable flow rate.

[0040] In an embodiment of the disclosure, the control device is provided with a control module configured to generate control signals for controlling the collective heat pump and for controlling each adjustable valve.

[0041] The advantages of the embodiments of the disclosure described above and/or the second aspect are also achieved with a heating and cooling system for collective residential housing units, which heating and cooling system is provided with: a collective heat pump, a plurality of residential housing units, each of which is provided with a heating and cooling system and a local control device for controlling it, one closed circuit for circulating a liquid between the collective heat pump and the heating and cooling systems of the residential housing units, a central control device for controlling the collective heat pump, for each residential housing unit, a supply branch from the closed circuit to the residential housing unit, each supply branch being provided with an adjustable valve for regulating a flow rate on the supply branch, the local control device being further configured to control of the controllable valve, wherein the central control device and each of the local control devices together form a control device, as described above.

[0042] In an embodiment of the disclosure, the collective heat pump comprises a plurality of air-water (generally air-liquid) heat pumps and/or water-water (generally liquid-liquid) heat pumps, in particular a monoblock heat pump, which are preferably arranged in parallel. Air-water heat pumps have many advantages, for example they can be placed and used anywhere without additional systems (such as a BEO field). The use of multiple air-water heat pumps also provides the necessary redundancy, e.g. if one heat pump is defective, this can be absorbed by the remaining ones. Placing the heat pumps in parallel is further advantageous because one or more of the heat pumps can easily be switched on or off depending on the actual needs. A defective heat pump can also easily be accommodated by the remaining one and can be repaired or replaced without impact on the rest of the system. Finally, the use of a monoblock heat pump increases safety and reduces the cost price. The refrigerant (or heating agent) is only present in one component, which is completely separated from the liquid in the closed loop, in which for example water can circulate. The installation of the system can therefore largely be done without the intervention of a specialized technician.

[0043] The use of water-to-water heat pumps, on the other hand, is advantageous in applications with geothermal energy, e.g. a BEO (Borehole Energy Storage) field or a KWO (Cold Heat Storage) field. Such geothermal applications require the use of a liquid-liquid heat pump. A common installation includes a single water-to-water heat pump between the BEO/KWO field and the residential housing units. The water-water heat pump has a high power (e.g. more than 100 kW) and only has an ON mode and an OFF mode. As a result, there is a need for a system of redundancies (e.g. expansion tanks, pressure vessels, spare vessels, etc.) to meet variable energy needs. Furthermore, frequency-controlled water-to-water heat pumps are also known that allow to meet a variable energy requirement via the variable frequency (i.e. a heat pump with a constant flow but a variable frequency to vary a difference in temperature between the incoming and outgoing liquid). However, its cost is not economically viable for use in collective residential housing units compared to the system of redundancies. In addition, this often creates situations in which the heat pump does not operate in optimal conditions.

[0044] The disclosure makes allows to replace one high-power heat pump with several low-power heat pumps (e.g. a power of about 5-20 kW, such as 10 kW). Furthermore, the redundancies are unnecessary in the context of the disclosure since the variable energy needs can be met by temporarily switching on or off certain heat pumps. In addition, multiple frequency-controlled water-to-water heat pumps can also be used that in this way, in addition to switching a heat pump on or off, respond even better to the variable energy need.

[0045] The use of both air-water (general air-liquid) and water-water (general liquid-liquid) heat pumps in the same system allows to make optimal use of them in dependence on weather conditions. To illustrate, the efficiency of an air-to-water heat pump for heating decreases with a decreasing outside temperature. A BEO/KWO field each have a maximum total energy capacity that must remain constant overall over one year. This is typically achieved by injecting the energy extracted in the winter for heating back into the field by cooling in the summer. For example, if the outside temperature is above 10°C, an air-to-water heat pump is sufficiently efficient so that these heat pump(s) can provide the system with the necessary energy and therefore no energy has to be extracted from the BEO/KWO field. At a lower temperature, it is then possible to switch to the water-to-water heat pump(s) that are more efficient than the air-to-air heat pumps at such temperatures. In the summer, if necessary, the air-to-water heat pump can be used as an additional source to inject energy into the BEO/KWO field by means of the water-water heat pump(s). This additional injection of energy into the BEO/KWO field by means of the air-to-water heat pumps in the summer can be advantageous for various reasons, e.g. as compensation for excess/exceptional use in the past winter or in a relatively cool summer where there is only little cooling, etc. and therefore generally serves to maintain the overall energy balance of the BEO/KWO field over the period of one year.

[0046] In an embodiment of the disclosure, the heating and cooling system is further provided with: one or more flow rate meters for determining the actual flow rate on the closed circuit on the output side of the collective heat pump, wherein the central control device is further configured to receive measurements from the one or more flow rate meters, and a local flow rate meter on each supply branch for measuring the flow thereon, the local control device being further configured to receive measurements from the local flow rate meter and transmit them to the central control device. By linking the central flow rate meter(s) with the central control device and each local flow rate meter with a corresponding local control device, the flow rate meters can use energy-efficient local communication technology. Preferably, a central flow rate meter is provided for each heat pump and the total flow rate on the output side of the collective heat pump is determined as the sum of all individual measurements.

[0047] The advantages of the embodiments of the disclosure described above and/or the second aspect are also achieved with a method for controlling a heating and/or cooling system for collective residential housing units, which method comprises the following steps: obtaining a actual flow rate in a closed circuit in which liquid circulates between a collective heat pump and the residential housing units, whereby each residential housing unit is connected to the closed circuit via a supply branch; obtaining maximum flow rate data on each supply branch, which maximum flow rate data are based on an energy requirement of the corresponding housing unit; determining a maximum flow rate for each residential housing unit based on the data obtained; and generating control signals for limiting the flow rate on each supply branch in accordance with the determined maximum flow rate.

[0048] In an embodiment of the disclosure, determining the maximum flow rate comprises: determining the total maximum flow rate by taking the sum of all maximum flow rate data; if the total maximum flow rate is less than the actual flow rate, determining the maximum flow rate of each residential housing unit as its maximum flow rate data; and if the total maximum flow rate is greater than the actual flow rate, determining the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, the fraction corresponding to a ratio between the actual flow rate and the total maximum flow rate. Preferably, the method further comprises: obtaining actual temperature data and desired temperature data from each residential housing unit and temperature data from the liquid at an output side of the collective heat pump; determining a status of each housing unit based on the actual temperature data and the desired temperature data, the status being one of the following: heating and cooling; and determining a status of collective heat pump based on the temperature data of the liquid on the output side of the collective heat pump, wherein the status is one of the following: heating and cooling, wherein the total maximum flow rate is determined by only residential housing units that have the same status as the collective heat pump. Preferably, the method further comprises: receiving an activation signal from one of the residential housing units, which activation signal comprises a request for a greater flow rate than the maximum flow rate data of said one of the housing units, wherein the total maximum flow rate is determined by taking said greater flow rate for said one of the housing units, and wherein, if the total maximum flow rate is less than the actual flow rate, the maximum flow rate of said one of the housing units is determined as said greater flow rate. The advantages of this have already been described above.

[0049] In a third aspect, the present disclosure concerns a control device for controlling a heating and/or cooling system for collective residential housing units, which heating and/or cooling system is provided with: a collective heat pump, a plurality of residential housing units, one closed circuit for circulating a liquid between the collective heat pump and the residential housing units, said closed circuit comprising a supply section and a discharge section, a bypass between the supply section and the discharge section for bypassing part of the liquid around the plurality of residential housing units, and an adjustable valve for regulating a flow rate over the bypass, wherein the control device is provided with: an interface configured to obtain actual flow rate data in the closed circuit; a database configured to store the actual flow rate data and one or more flow rate threshold values on the closed loop; an analysis module configured to determine, based on the stored flow rate data, an evolution of the flow during a past time interval; a decision module configured to determine a flow rate over the bypass, based on the evolution and the flow rate threshold values; and a control module configured to generate control signals for controlling the adjustable valve, based on said flow rate.

[0050] Providing an adjustable valve for regulating a flow rate over the bypass is an improvement on the already known bypass in which an ON/OFF valve is present. Firstly, the adjustable valve allows multiple flow rates between the OFF position (no flow) or the ON position (maximum flow rate). Secondly, the control device is able to monitor the flow rate in the closed circuit over time and thus gradually adjust the adjustable valve on the bypass according to the evolution. For example, the adjustable valve can be opened gradually with a decreasing flow rate, instead of immediately opening completely as with the known valve, which fully open position may remove too much flow, resulting in insufficient heating and/or cooling for the residential housing units.

[0051] In an embodiment of the disclosure, a corresponding flow rate over the bypass is stored in the database for each threshold flow rate value. The decision module can easily and quickly consult this information, e.g. in the form of a query table, to determine the necessary flow rate over the bypass.

[0052] In an embodiment of the disclosure, said evolution is one of: decreasing, stable and increasing, and wherein the database is configured to store a different set of flow rate threshold values for each evolution. The decision module is preferably configured: to increase the flow rate over the bypass in the event of a downward trend; in the event of an increasing trend, to reduce the flow rate over the bypass; and with a stable evolution, to leave the flow rate through the bypass virtually unchanged. The use of different sets of flow rate threshold values allows the flow rate over the bypass to be adjusted based on actual conditions. To illustrate, although a low flow rate in the closed circuit (e.g. below a general flow rate threshold value) may pose a risk to the operation of the collective heat pump, the status of the evolution may indicate not to send any flow rate through the bypass. In particular, if the evolution is increasing, the low flow rate threshold value may be higher than with a decreasing evolution, since the risk for the collective heat pump is lower with the increasing evolution.

[0053] In an embodiment of the disclosure, the heating and/or cooling system is further provided with, for each residential housing unit, a supply branch from the closed circuit to the residential housing unit, each supply branch being provided with an adjustable valve for regulating a flow rate on the supply branch, wherein the interface is further configured to obtain actual flow rate data from each supply branch, wherein the decision module is further configured to take into account the actual flow rate data from each supply branch when determining the flow rate over the bypass supply branch. The use of the actual flow rate data on the supply branches allows the decision module to anticipate a decreasing or increasing flow rate on the closed circuit. Particularly in the case of drastic adjustments in many residential housing units, analysing the evolution may not detect the shock effect of the drastic adjustments in time, resulting in a risk to the operation of the collective heat pump.

[0054] In an embodiment of the disclosure, the controllable valve can be adjusted almost continuously between an open position and a closed position. This increases control over the flow rate control.

[0055] In an embodiment of the disclosure, the control device is configured for controlling a heating and cooling system for collective residential housing units. As already described, one joint system has advantages over two separate systems, namely one for heating and one for cooling.

[0056] In an embodiment of the disclosure, the database is configured to store a different set of flow rate threshold values for each status of the collective heat pump, wherein the status is one of the following: heating and cooling. This also allows the specificity of a collective heat pump for heating or cooling to be taken into account when determining the flow rate over the bypass.

[0057] The advantages of the embodiments of the disclosure described above and/or the second aspect are also achieved with a heating and cooling system for collective residential housing units, which heating and cooling system is provided with: a collective heat pump, a plurality of residential housing units, each of which is provided with a heating and cooling system and a local control device for controlling it, one closed circuit for circulating a liquid between the collective heat pump and the heating and cooling systems of the residential housing units, which closed circuit comprises a supply section and a discharge section, an adjustable valve for regulating a flow rate over the bypass, and a control device, as described above, for controlling the adjustable valve.

[0058] In an embodiment of the disclosure, the collective heat pump comprises a plurality of air-water (generally air-liquid) heat pumps and/or water-water (generally liquid-liquid) heat pumps, in particular a monoblock heat pump, which are preferably arranged in parallel. Air-water heat pumps have many advantages, for example, they can be placed and used anywhere without additional systems (such as a BEO field). The use of multiple air-water heat pumps also provides the necessary redundancy, e.g. if one heat pump is defective, this can be absorbed by the remaining ones. Placing the heat pumps in parallel is further advantageous because one or more of the heat pumps can easily be switched on or off depending on the actual needs. A defective heat pump can also easily be accommodated by the remaining one and can be repaired or replaced without impact on the rest of the system. Finally, the use of a monoblock heat pump increases safety and reduces the cost price. The refrigerant (or heating agent) is only present in one component, which is completely separated from the liquid in the closed loop, in which for example water can circulate. The installation of the system can therefore largely be done without the intervention of a specialized technician.

[0059] The use of water-to-water heat pumps, on the other hand, is advantageous in applications with geothermal energy, e.g. a BEO (Borehole Energy Storage) field or a KWO (Cold Heat Storage) field. Such geothermal applications require the use of a liquid-liquid heat pump. A common installation includes a single water-to-water heat pump between the BEO/KWO field and the residential housing units. The water-water heat pump has a high power (e.g. more than 100 kW) and only has an ON mode and an OFF mode. As a result, there is a need for a system of redundancies (e.g. expansion tanks, pressure vessels, spare vessels, etc.) to meet variable energy needs. Furthermore, frequency-controlled water-to-water heat pumps are also known that allow to meet a variable energy requirement via the variable frequency (i.e. a heat pump with a constant flow but a variable frequency to vary a difference in temperature between the incoming and outgoing liquid). However, its cost is not economically viable for use in collective residential housing units compared to the system of redundancies. In addition, this often creates situations in which the heat pump does not operate in optimal conditions.

[0060] The disclosure makes allows to replace one high-power heat pump with several low-power heat pumps (e.g. a power of about 5-20 kW, such as 10 kW). Furthermore, the redundancies are unnecessary in the context of the disclosure since the variable energy needs can be met by temporarily switching on or off certain heat pumps. In addition, multiple frequency-controlled water-to-water heat pumps can also be used that in this way, in addition to switching a heat pump on or off, respond even better to the variable energy need.

[0061] The use of both air-water (general air-liquid) and water-water (general liquid-liquid) heat pumps in the same system allows to make optimal use of them in dependence on weather conditions. To illustrate, the efficiency of an air-to-water heat pump for heating decreases with a decreasing outside temperature. A BEO/KWO field each have a maximum total energy capacity that must remain constant overall over one year. This is typically achieved by injecting the energy extracted in the winter for heating back into the field by cooling in the summer. For example, if the outside temperature is above 10°C, an air-to-water heat pump is sufficiently efficient so that these heat pump(s) can provide the system with the necessary energy and therefore no energy has to be extracted from the BEO/KWO field. At a lower temperature, it is then possible to switch to the water-to-water heat pump(s) that are more efficient than the air-to-air heat pumps at such temperatures. In the summer, if necessary, the air-to-water heat pump can be used as an additional source to inject energy into the BEO/KWO field by means of the water-water heat pump(s). This additional injection of energy into the BEO/KWO field by means of the air-to-water heat pumps in the summer can be advantageous for various reasons, e.g. as compensation for excess/exceptional use in the past winter or in a relatively cool summer where there is only little cooling, etc. and therefore generally serves to maintain the overall energy balance of the BEO/KWO field over the period of one year.

[0062] In an embodiment of the disclosure, the heating and cooling system is further provided with: one or more flow rate meters for determining the actual flow rate on the closed circuit on the output side of the collective heat pump, wherein the control device is further configured to receive measurements from the one or multiple flow rate meters. Preferably, a flow rate meter is provided for each heat pump and the total flow rate on the output side of the collective heat pump is determined as the sum of all individual measurements. By connecting the flow rate meter(s) to the control device, it can use energy-efficient local communication technology.

[0063] In an embodiment of the disclosure, the heating and cooling system is further provided with: for each residential housing unit, a local flow rate meter for measuring a flow from the closed loop to the residential housing unit, wherein the local control device is further configured to receive measurements from the local flow rate meter and forward it to the control device. As already described, this allows the control device to anticipate a decreasing or increasing flow rate on the closed circuit.

[0064] The advantages of the embodiments of the disclosure described above and/or the second aspect are also achieved with a method for controlling a heating and/or cooling system for collective residential housing units, which method comprises the following steps: obtaining flow rate data in a closed circuit that circulates liquid between a collective heat pump and the residential housing units and one or more flow rate threshold values on the closed circuit; determining an evolution of the flow rate over a past time interval on the basis of the flow rate data; and determining a flow rate over a bypass in the closed circuit on the basis of the evolution and the flow rate threshold values for bypassing part of the liquid around the plurality of residential housing units.

[0065] In an embodiment of the disclosure, the evolution is one of: decreasing, stable and increasing, and wherein determining the flow rate over the bypass comprises: in the event of a decreasing evolution, increasing the flow rate over the bypass; in the event of an increasing trend, reducing the flow rate over the bypass; and with a stable evolution, leaving the flow rate through the bypass virtually unchanged. The advantages of this have already been described.

[0066] In an embodiment of the disclosure, the method further comprises: obtaining actual flow rate data from the closed circuit to each residential housing unit, whereby these actual flow rate data are also used in determining the flow rate over the bypass. The advantages of this have already been described.

[0067] It should be clear that, as will also become apparent from the further description below, the above-identified aspects of the disclosure and the various embodiments of the disclosure (including any optional features indicated) are not separate elements, but, on the contrary, that these different elements can be mutually combined to obtain embodiments of the disclosure other than those already described, which embodiments of the disclosure also form part of the present disclosure.

Brief description of the drawings

[0068] The disclosure will hereinafter be explained in further detail on the basis of the following description and the accompanying drawings.

Figure 1 shows a schematic overview of a heating and cooling system for collective residential housing units according to the present disclosure.

Figure 2 shows a flowchart of a first method for controlling the temperature in the closed loop in a heating and cooling system for collective residential housing units according to the present disclosure.

Figure 3 shows a flowchart of a second method for controlling the temperature in the closed loop in a heating and cooling system for collective residential housing units according to the present disclosure.

Figure 4 shows a flowchart of a method for regulating the maximum flow rates on the branches of the closed circuit in a heating and cooling system for collective residential housing units according to the present disclosure.

Figure 5 shows a flowchart of a method for regulating a flow rate on a closed loop bypass in a heating and cooling system for collective residential housing units according to the present disclosure.

Figure 6 shows a schematic overview of the functional components in a control device for controlling a heating and cooling system for collective residential housing units according to the present disclosure.

Embodiments of the Disclosure

[0069] The present disclosure will hereinafter be described with reference to specific embodiments and with reference to certain drawings, but the disclosure is not limited thereto and is defined by the claims only. The drawings shown here are only schematic representations and are not restrictive. In the drawings, the dimensions of certain parts may be shown enlarged, which means that the parts in question are not shown to scale and this is for illustrative purposes only. The dimensions and relative dimensions do not necessarily correspond to actual practical embodiments of the disclosure.

[0070] In addition, terms such as "first", "second", "third", and the like are used in the description and in the claims to distinguish between similar elements and not necessarily to indicate a sequential or chronological order. The terms herein are interchangeable in appropriate circumstances, and embodiments of the disclosure may operate in different sequences than those described or illustrated herein.

[0071] In addition, terms such as "top," "bottom," "top," "bottom," and the like are used in the description and in the claims for descriptive purposes. The terms so used are interchangeable in appropriate circumstances, and the embodiments of the disclosure may operate in other orientations than those described or illustrated herein.

[0072] The term "comprising" and derivative terms, as used in the claims, shall not be construed as being limited to the means set forth in each case thereafter; the term does not exclude other elements or steps. The term shall be interpreted as a specification of the stated properties, integers, steps, or components referred to, without excluding the presence or inclusion of one or more additional properties, integers, steps, or components, or groups thereof. The scope of an expression such as "a device comprising means A and B" is therefore not limited solely to devices consisting purely of components A and B. What is meant, on the other hand, is that, as far as the present disclosure is concerned, the only relevant components are A and B.

[0073] The term "approximately" comprises variations of +/- 10% or less, preferably +/-5% or less, more preferably +/-1% or less, and more preferably +/-0.1% or less, of the specified condition, to the extent that the variations are applicable to function in the present disclosure. It should be understood that the term "substantially A" is intended to include "A".

[0074] Figure 1 shows a schematic overview of a heating and cooling system 100 for collective residential housing units according to the present disclosure. It is to be understood that, although the description hereinafter refers to a combined heating and cooling system, certain aspects of the present disclosure may also be applied to a system solely for heating or cooling. In particular, the methods described below with reference to Figures 3 and 4 are suitable for application to a system that serves exclusively for heating or cooling, while the method described below with reference to Figure 2 is only suitable for application to a combined heating and cooling system.

[0075] The system 100 comprises a collection of residential housing units 120_1, 120_2,..., 120_N, hereinafter jointly referred to as reference number 120, wherein N is a natural number greater than 1. This collection 120 may be formed by several apartments in one or more apartment buildings and/or several separate residential buildings. Each of the housing units 120 is equipped with a separate heating and cooling system 124. Examples are such as classic radiators, underfloor heating, underfloor cooling, convectors, etc. The heating and cooling system 124 preferably uses liquid circulation, e.g. underfloor and/or wall circulation, such that both heating and cooling are possible via the same system.

[0076] The different housing units 120 can be identical to each other or different from each other. For example, it is possible that one or more of the housing units 120 have an additional separate system 125 for heating water, e.g. a boiler, which is in energetic connection with the heating and cooling system 124. This allows, for example, for water to be heated to 60°C, 70°C or 80°C for use as a shower while the heating and cooling system 124 uses water at 35°C for heating.

[0077] The system 100 also comprises a central collective component 110 comprising a collective heat pump 114 that is connected to each of the residential housing units 120 via a network of conduits indicated with reference numbers 130 et seq. The network of conduits together forms a closed circuit 130 for circulation of a liquid between the collective heat pump 114 and each of the local heating and cooling systems 124. The closed circuit 130 comprises a supply section 130A for supplying liquid to the housing units 120 and a discharge section 130B for removing liquid from the housing units 120. A plurality of supply branches 132_1, 132_2,..., 132_N are provided on the supply section 130A (hereinafter collectively referred to as reference numeral 132), each of which connects one housing unit to the supply section 130A of the closed circuit 130. On the discharge section 130B, a plurality of supply branches 134_1, 134_2,..., 134_N are also provided (hereinafter collectively referred to as reference numeral 134), each of which connects one housing unit to the discharge section 130B of the closed circuit 130. Furthermore, in the embodiment of the disclosure shown, there is a bypass 136 from the supply section 130A to the discharge section 130B. The function of this bypass 136 is described further and it should be understood that, in other embodiments, this bypass may be absent.

[0078] The conduits 130, 132, 134, 136 can be made from different materials, including plastic, composite, cement and/or metal. The conduits can be single- or multi-walled. If necessary, insulation can also be provided around (part of) the conduits. The conduits are preferably laid underground as often as possible, because this is advantageous in terms of insulation and is aesthetically desirable.

[0079] The conduits are preferably suitable for transporting both a hot and cold liquid. In an embodiment of the disclosure, the liquid is water, but other liquids are also possible. Preferably, these are liquids that do not freeze at room temperature, such as ammonia, oil, alcohol or glycol. In an embodiment of the disclosure, the warm liquid has a temperature between 5 and 50 °C, which temperature is in particular at least 15 °C, more particularly at least 20 °C and most particularly at least 25 °C and which temperature is in particular is not more than 45 °C and more specifically not more than 40 °C. An example of a warm medium temperature is 30 °C, 31 °C, 32 °C, 33 °C, 34 °C or 35 °C. In an embodiment of the disclosure, the cold liquid has a temperature between 0 and 35 °C, which temperature is in particular at least 3 °C, more particularly at least 5 °C and most particularly at least 8 °C and which temperature is in particular not more than 20 °C, more particularly not more than 15 °C and most particularly not more than 10 °C. An example of a temperature of a cold medium is 9 °C.

[0080] Each housing unit 120 is further provided with a plurality of sensors 126_1,..., 126_J, hereinafter collectively referred to as reference number 126, wherein J is a natural number greater than 1. Which and/or the number of sensors 126 may differ per housing unit 120, such as in the embodiment of the disclosure shown in Figure 1 wherein L sensors are provided in housing unit 120_1, J sensors are provided in housing unit 120_N and K sensors are provided in housing unit 1202, wherein J, K and L are each a natural number greater than 1 and can be different or equal to each other. Each of the sensors described below determines, directly or indirectly (e.g. through the use of a mathematical formula or a correlation), a numerical value for a physical quantity. In what follows, the output of the one or more sensors is referred to as sensor data.

[0081] In the context of the present disclosure, the following sensors 126 may be relevant. With reference to Figures 2 through 5, it will become clear which of the sensors 126 mentioned below are important. One or more sensors for measuring the temperature in one or more spaces inside the housing unit and/or outside the housing unit. One or more sensors for measuring the humidity in one or more spaces inside the housing unit and/or outside the housing unit. One or more sensors for measuring the CO_2 level in one or more spaces inside the housing unit and/or outside the housing unit. One or more sensors for measuring the particulate matter content in one or more spaces inside the housing unit and/or outside the housing unit. One or more sensors for measuring a flow rate in one or more conduits, in particular on the supply branch 132 to the housing unit. One or more sensors for measuring a pressure in one or more conduits, in particular on the supply branch 132 to the housing unit. One or more sensors for detecting a presence in one or more spaces within the housing unit, e.g. an infrared detector, a camera, a heat detector, the presence of a smartphone, etc. One or more sensors for detecting light and/or light intensity in one or more spaces within the housing unit.

[0082] Each housing unit 120 is further provided with a plurality of actors 128_1,..., 128_P, hereinafter collectively referred to as reference number 128, wherein P is a natural number greater than 1. Which and/or the number of actors 128 may differ per housing unit 120, such as in the embodiment of the disclosure shown in Figure 1, wherein R actors are provided in housing unit 120_1, P actors are provided in housing unit 120_N and Q actors are provided in housing unit 120_2, wherein P, Q and R are each a natural number greater than 1 and can be different or equal to each other. Each actor 128 directly or indirectly controls one or more devices (or part thereof) that are related to and/or have an influence on the heating and cooling system 124. In what follows, the setting of the one or more actors referred to as operating data.

[0083] In the context of the present disclosure, the following devices may be relevant to the operation of the heating and cooling system 124. Firstly, the heating and cooling system 124 itself, e.g. the floor circulation or an HVAC. In addition, the following devices may also be relevant: a ventilation system, a sun protection system and an air conditioning system, or a combination thereof. Which actors are present naturally depends on the devices present in the housing unit. Examples of actors are flow rate controllers, in particular a flow rate controller on the supply branch 132 to the housing unit, valves, fan motor, a drive for the sun blinds, rotating slats, ventilation grilles, etc. Examples of the operating data are: the flow rate, the position of the valves or the rotating slats, the position of a sun blind, the power of the fan motor, the position of a ventilation grille, etc.

[0084] In addition to sensor data and operating data, there are also external data that are related to or may have an influence on the operation of the heating and cooling system 124. Examples comprise: outside temperature, air pressure, ambient air quality (e.g. particulate matter content), weather forecast, actual or expected energy prices, input from sensors external to the housing unit, feedback from residents and/or other users, etc.

[0085] Another type of data in the context of the present disclosure is user data. In particular, they represent the conditions desired by the user within the housing unit or within a specific space therein. Typically, the desired condition relates to the temperature, e.g. the occupant of a housing unit desires a temperature of 21 °C in the period between 6:30 am and 8:30 am and between 4:00 pm and 9:00 pm, while at other times, the temperature may be lower or higher, e.g. 18 °C or 25 °C. Another example is the desire for a constant temperature between 20 °C and 23 °C during the day, e.g. between 7 am and 8 pm.

[0086] The data, in particular the sensor data and operating data, are typically obtained sequentially or presented as a series of values as a function of time. The values may be obtained periodically, e.g. one value per minute, although a regular interval is not crucial.

[0087] In each housing unit 120, a local control device 122 is further provided for controlling the heating and cooling system 124. Figure 6 schematically illustrates which functional components are present in the local control device 122.

[0088] The local control device 122 is generally a computer system comprising a bus 602, a processor 604, a local memory 606, one or more input/output (I/O) interfaces 608, and a communications interface 610. The bus 602 comprises one or more multiple conductors and allows communication between the different components of the computer system. Processor 604 comprises any type of conventional processor or microprocessor that reads and executes computer program instructions. Local memory 606 is intended to comprise any form of computer-readable information storage medium, such as a working memory (e.g., Random Access Memory - RAM), a static memory (e.g., a Read-Only Memory - ROM), a hard drive, or removable storage media (e.g. a DVD, CD, USB storage, SSD, etc.), etc. The local memory 606 typically serves to store information and instructions to be processed by the processor. The I/O interface 608 may comprise one or more conventional systems that enable communication between the local control device 122 and a user 160. Examples comprise a keyboard, a mouse, speech recognition, biometrics, a (touch) screen, a printer, a speaker, etc. The communication interface 610 is typically a transceiver system that allows communication with external systems. Examples are a Wide Area Network (WAN), such as the Internet, a Low Power Wide Area Network (LPWAN) such as Sigfox, LoRa, NarrowBand IoT, etc., a Personal Area Network (PAN) such as Bluetooth, or a Local Area Network (LAN).

[0089] In the embodiment shown, the local control device 122 further comprises a number of interfaces together indicated with reference number 620. More specifically, there is a first interface 612 for obtaining the sensor data from the one or more sensors 126, a second interface 614 for obtaining the operating data from the one or more actors 128, a third interface 616 for obtaining the external data from one or more external sources 150, and a fourth interface 618 for obtaining the user data from a user 160. Each of the interfaces described above can collect data wirelessly or via a cable or even via a combination of both wherein data from certain sensors/actors/sources is collected wirelessly and from other sensors/actors/ sources via one or more cables. Each of these interfaces may use the I/O interface 608 and/or the communications interface 610.

[0090] The local memory 606 can serve for the (temporary) storage of the data collected via the interfaces 620. For example, the collected data can be stored for a predetermined period (e.g. one hour, one day or one week) before being sent to an external database. How long collected data is stored and/or how frequently collected data is sent to an external database depends on the desire to store as little data as possible locally and/or to limit external communications. It is also possible to forward certain collected data to the external database on an (almost) continuous basis.

[0091] The processor 604 further comprises a control module 622 that is configured to generate control signals for one or more of the actors 128. If necessary, the processor 604 can use the communication interface 610 to send these control signals to the actors 128.

[0092] As already described above, the system 100 comprises a collective heat pump 114 for bringing the liquid in the closed circuit 130 to the desired temperature. In the context of the disclosure, this may be a liquid-liquid heat pump, in particular a plurality of parallel monobloc water-water heat pumps, used in combination with or as part of a BEO (Borehole Energy Storage) field or a KWO (Cold Heat Storage) field. However, the disclosure is mainly directed to the situation wherein the collective heat pump 114 is formed by an air-water heat pump. In the embodiment of the disclosure shown, the collective heat pump 114 comprises several separate air-water heat pumps 114_1, 114_2, 114_3,..., 114_M, wherein M is a natural number greater than 1. These are preferably arranged in parallel. Further preferably, each air-water heat pump is a monoblock heat pump.

[0093] The central collective component 110 further comprises a plurality of sensors 116_1,... 116_S, hereinafter collectively referred to as reference numeral 116, wherein S is a natural number greater than 1. Each of the sensors described below determines directly or indirectly (e.g. via use of a mathematical formula or a correlation) a numerical value for a physical quantity. In what follows, the output of the one or more sensors is referred to as sensor data.

[0094] In the context of the present disclosure, the following sensors 116 may be relevant. With reference to Figures 2 through 5, it will become clear which of the sensors 116 mentioned below are important. One or more sensors for measuring the temperature of the liquid in the closed circuit 130, in particular on the input and/or output side of the collective heat pump 114, and optionally also for measuring the liquid temperature between successive heat pumps. One or more sensors for measuring a flow rate in the closed circuit 130, in particular on the output side of the collective heat pump 114 and/or on the bypass 136.

[0095] The central collective component 110 further comprises a plurality of actors 118_1, ... 118_T, hereinafter collectively referred to as reference number 118, wherein T is a natural number greater than 1. Each actor 118 directly or indirectly controls one or more elements related to and/or may have an influence on the collective heat pump 114 and/or the flow on the bypass 136. Examples are flow rate controllers on the closed circuit 130 and/or the bypass 136, power settings of the collective heat pump 114 or of the individual heat pumps that are part of it, etc. In what follows, the setting of one or more actors is referred to as operating data.

[0096] The central collective component 110 also comprises a central control device 112 for controlling the collective heat pump 114. Figure 6 schematically illustrates which functional components are present in the central control device 112.

[0097] The central control device 112 is generally a computer system comprising a bus 652, a processor 654, a central memory 656, one or more input/output (I/O) interfaces 658, and a communications interface 660. The bus 652 comprises one or more multiple conductors and allows communication between the different components of the computer system. Processor 654 comprises any type of conventional processor or microprocessor that reads and executes computer program instructions. Local memory 656 is intended to comprise any form of computer-readable information storage medium, such as a working memory (e.g. Random Access Memory - RAM), a static memory (e.g. a Read-Only Memory - ROM), a hard drive, or removable storage media (e.g. a DVD, CD, USB storage, SSD, etc.), etc. The local memory 656 typically serves to store information and instructions to be processed by the processor. The I/O interface 658 may comprise one or more conventional systems that enable communication between the central controller 112 and an administrator 170. Examples comprise a keyboard, a mouse, speech recognition, biometrics, a (touch) screen, a printer, a speaker, etc. The communication interface 660 is typically a transceiver system that allows communication with external systems. Examples are a Wide Area Network (WAN), such as the Internet, a Low Power Wide Area Network (LPWAN) such as Sigfox, LoRa, NarrowBand IoT, etc., a Personal Area Network (PAN) such as Bluetooth, or a Local Area Network (LAN).

[0098] In the embodiment shown, the central control device 112 further comprises a number of interfaces collectively indicated by reference numeral 670. More specifically, there is a first interface 672 for obtaining data from the various local control devices 122, a second interface 674 for obtaining sensor data from the one or more sensors 116, and a third interface 676 for obtaining the operating data from the one or more actors 118. Each of the interfaces described above can collect data in a wireless or wired manner or even a combination of both. Each of these interfaces can use the I/O interface 658 and/or the communication interface 660.

[0099] The central memory 656 can serve for the (temporary) storage of the data collected via the interfaces 670. In the embodiment shown, the central memory 656 comprises the following modules: a long-term storage 662, a housing unit-specific data storage 664, a user-preferences storage 666, and collective heat pump operating conditions storage 668. The long-term storage 662 serves to store historical data. (e.g. sensor data, operating data, external data and/or user data), which data is then stored as a time series and can cover a period of days, weeks, months or even years. The housing unit-specific data storage 664 serves to store data that is unique to a housing unit, e.g. its orientation, maximum or average energy requirements for heating, maximum or average energy requirements for cooling, energy retention of the housing unit, etc. In other words, the housing unit specific data storage 664 comprises a set of data per housing unit. The user-preference storage 666 serves to store preferences of residents/users of a housing unit, e.g. a schedule of the desired temperature per day of the week. In other words, the user-preference storage 666 comprises at least one set of data per housing unit and may, if necessary, contain multiple sets per housing unit, namely a first set for a first resident and a second (possibly different set) for a second resident of the same housing unit. The collective heat pump operating conditions storage 668 contains data regarding the operating conditions for the collective heat pump 114, e.g. minimum and/or maximum flow rates, optimal incoming/outgoing liquid temperature, desired power, etc. The function of these specific modules is described below with reference to Figures 2 through 5.

[0100] The processor 654 further comprises a control module 682 that is configured to generate control signals for one or more of the actors 118. If necessary, the processor 654 can use the communication interface 660 to send these control signals to the actors 118. The processor 654 in the embodiment of the disclosure shown also comprises an analysis module 684, a machine learning module 686, and a decision module 688. The analysis module 684 typically serves to analyse certain parameters of the system 100 to determine a trend therein or a need. The machine learning module 686 typically comprises a form of artificial intelligence (e.g., a neural network) that can recognize patterns and/or make predictions about user preferences, properties of a housing unit, based on the historical data available in the long-term storage 662 etc. The decision module 688 serves to make a decision about one or more settings of actors on the basis of a set of parameters or values. The decision module 688 can be rule-based, but can also use artificial intelligence, e.g. a neural network. The function of these specific modules is discussed below with reference to Figures 2 through 5.

[0101] Figure 2 shows a flowchart of a first method 200 for controlling the liquid temperature in the closed circuit 130 in the heating and cooling system 100. The method 200 is control-based and serves to control the collective heat pump 114 on the basis of actual temperature data and user data regarding temperature in the housing units

120 in combination with actual and historical temperature data of the liquid in the closed circuit 130, in particular on the output side of the collective heat pump 114.

[0102] In a first step of the method 200, the central control device 112 collects (202) data regarding the actual temperature in the housing units 120 or in certain spaces thereof. This can be done, for example, via the thermometers 126 present in the housing units 120, whose data are sent by the local control devices 122 to the central control device 112.

[0103] In step 202, data is also collected about the temperature desired by a resident (or user) of the housing units. This data can be obtained in various ways. Classically, the resident has pre-entered a schedule into the local controller 122, which schedule comprises a summary of the desired temperature at any time of the day for each day of the week. This schedule is preferably also stored in the user preferences storage module 666 in the central memory 656. The resident can adjust this schedule via the I/O module 608, after which an update can take place in the user preferences storage module 666. Via the I/O module 608, the resident can also temporarily deviate from the schedule, after which the local control device 122 passes on this deviation to the central control device 112. It is also possible that the machine learning module 686, based on the historically stored desired temperature data in the long term storage 662, predicts the temperature desired by a resident at the actual time or that the machine learning module 686 proposes its own weekly schedule. This schedule can then replace the actual schedule, for example after validation by the resident.

[0104] In step 204, the processor 654, in particular the analysis module 684, calculates the difference value between the actual temperature in the housing units and the desired temperature in order to determine the general need. In an embodiment, both the sum of the actual temperature in each housing unit and the sum of the desired temperature in each housing unit are calculated. The sum of the actual temperatures is then subtracted from the sum of the desired temperatures to obtain the temperature difference value. If the temperature difference value is positive, this means that there is a general need for heating, while a negative temperature difference value corresponds to a general need for cooling. Of course, the difference can also be taken the other way around.

[0105] In step 206, the processor 654, in particular the decision module 688, checks whether the temperature difference value is positive or negative. In an embodiment (indicated by the dotted lines in Figure 2), the method 200 proceeds directly to step 214. More specifically, if the temperature difference value is positive, then the decision module 688 decides that warm liquid should circulate in the closed circuit 130, option 214A. In step 214A, the necessary control signals are thus generated by the control module 682 and sent to the actors 118 of the collective heat pump 114 such that a warm liquid circulates in the supply section 130A of the closed circuit 130. However, if the temperature difference value is negative, then the decision module 688 decides that cold liquid should circulate in the closed loop 130, option 214B. In step 214B, the necessary control signals are thus generated by the control module 682 and sent to the actors 118 of the collective heat pump 114 such that a cold liquid circulates in the supply section 130A of the closed circuit 130.

[0106] In the embodiment of the disclosure shown (solid lines in Figure 2), the method continues from step 206 to step 208. Step 208 is a further data collection step wherein the central control device 112 collects data regarding the actual temperature of the liquid in the closed circuit 130, in particular in its supply section 130A. This can be done via a thermometer 116, present on the output side of the collective heat pump 114, or by checking the actual settings of the relevant actors 118.

[0107] In step 210, the processor 654, in particular the decision module 688, checks which of four possible situations is actually present. More specifically, in situation 210A, the temperature difference value is positive and hot liquid is circulating; in situation 210B, the temperature difference value is positive and cold liquid is circulating; in situation 210C, the temperature difference value is negative and warm liquid circulates; and in situation 210D, the temperature difference value is negative and cold liquid is circulating. In situations 210A and 210D, no global adjustment is therefore necessary, i.e. there is a need for heating/cooling and circulating as hot/cold liquid. The method then proceeds to step 214 for generating the necessary control signals as already described.

[0108] In situations 210B and 210C, a global adjustment is necessary, namely there is a need for heating but cold liquid is circulating (situation 210B) or vice versa (situation 210C). In this situation, the processor 654 performs an additional analysis on the historical data of the collective heat pump 114. More specifically, it is checked (step 212) whether a changeover has already taken place recently (e.g. in the past hour or in the past 2 or 3 hours) from warm liquid to cold liquid (or vice versa). If there has been a change recently, it is not desirable to carry out a changeover again. This is because a great deal of energy is required to change the temperature of the liquid in the closed circuit 130. The decision module 688 thus decides, if there was a recent change (212A), to keep the actual setting (hot/cold), and if there was no recent change (212B), to adjust the setting. The method then proceeds to step 214 for generating the necessary control signals as already described.

[0109] In an advantageous embodiment of the disclosure, the central control device 112 can forward information about this decision to the local control devices 122 (step 216), e.g. via the communication interface 660. In this way, each of the local control devices 122 obtains information about which energy flow will arrive in the future, i.e. hot or cold liquid. In this way, each local control device 122 can anticipate and, depending on the desired temperature to be achieved, whether or not circulate liquid from the closed circuit 130 to the housing unit 120. For example, if the resident wishes a temperature of 21 °C, while the actual temperature is 23 °C (i.e. there is a need for cooling), and the corresponding local control device 122 is informed about the circulation of warm liquid in the closed circuit 130, a local decision can be made to reduce the flow rate on the supply branch 134 or even stop it completely. Alternatively, step 216 can be omitted and each local control device 122 must determine the temperature of the liquid on the supply branch 134 in order to make a decision regarding the flow rate through that branch.

[0110] It may also be advantageous to use the absolute value of the temperature difference value calculated in step 204 to control the collective heat pump 114. More specifically, the higher this absolute value (or the absolute value divided by the number of housing units), the more there is a need for heating or cooling. This can be taken into account by the decision module 688 to determine the exact temperature of the hot or cold liquid, e.g. by increasing or decreasing it by a number of °C. This information is then comprised in step 214 for generating the necessary control signals.

[0111] Figure 3 shows a flowchart of a second method 300 for controlling the liquid temperature in the closed loop 130 in the heating and cooling system 100. The method 300 serves to control the collective heat pump 114 by generating a temperature-time profile of the desired temperature of the liquid in the closed circuit 130, in particular on an output side of the collective heat pump 114, as a function of time during a future time interval. In other words, while the method 200 serves to perform a control (or regulation) at the actual time, the method 300 takes it one step further and provides a control (or regulation) during a future time interval (e.g., for the next hour or the next two or three hours).

[0112] In a first step of the method 300, the central control device 112 collects (302) data regarding the actual temperature in the housing units 120 or in certain spaces thereof. This can be done, for example, via the thermometers 126 present in the housing units 120, whose data are sent by the local control devices 122 to the central control device 112.

[0113] In step 302, data is also collected regarding the temperature desired by an occupant (or user) of the housing units. This data can be obtained in various ways. Classically, the resident has entered a schedule in advance into the local control device 122, which schedule comprises an overview of the desired temperature at any time of the day for each day of the week. This schedule is preferably also stored in the user preferences storage module 666 in the central memory 656. The resident can adjust this schedule via the I/O module 608, after which an update in the user preferences storage module 666 can be made. Via the I/O module 608, the resident can also temporarily deviate from the schedule, after which the local control device 122 passes on this divergence to the central control device 112. It is also possible that the machine learning module 686, based on the historically stored desired temperature data, in the long term storage 662, makes a prediction of a resident's desired temperature at the actual time or whether the machine learning module 686 proposes its own weekly schedule. This schedule can then replace the actual schedule, for example after validation by the resident.

[0114] In step 302, data is preferably also collected about the temperature desired by a resident (or user) of the housing units during a future time interval, in particular the same time interval for which a temperature-time profile is to be generated.

[0115] Step 302 is followed by a further step for collecting data (step 304), namely data regarding energy loss properties of each housing unit. Energy loss refers to numerical data regarding the heat loss and/or cold loss of a housing unit. For example, energy loss can be described as a curve that shows the evolution of temperature in a housing unit (or space therein) as a function of time without input of additional energy in a specific circumstance (e.g. presence of people, status of sun blinds, climate, the actual weather, the insulation of the home, time of day, etc.). Such data regarding energy loss of each housing unit can be predetermined, e.g. depending on the type of housing unit (terraced house, detached house, apartment, etc.), depending on the location, depending on the season, depending on the insulation of the home, etc. For example, a technician can enter a number of parameters of the home into the local control device 122 and the central control device 112 has a large database from which the most appropriate energy loss data is assigned to the housing unit based on the entered parameters. The selected energy loss data is then stored in the housing unit specific data storage 664.

[0116] However, preferably, the machine learning module 686 plays a role in obtaining the energy loss data. Hereto, the machine learning module 686 uses the historical data in the long-term storage 662 to estimate the energy loss of each housing unit during a future time interval, specifically the same time interval for which a temperature-time profile is to be generated. The advantage of this is that the energy loss data is not static and can take into account the actual situation in each housing unit, e.g. is someone actually present, are the sun blinds open or closed, what are the strict temperature margins of the residents (e.g. 1 °C or 4 °C tolerance), etc.

[0117] There are several possible ways to use the machine learning module 686 to estimate the energy loss data. One way is to analyse the historical data looking for a point in time with identical (or at least very similar) conditions (i.e. weather conditions, season, presence, actual indoor temperature, desired temperature, etc.). If a sufficiently similar set of conditions is identified in the historical data, the machine learning module 686 can determine how much energy was used by the housing unit (or a similar housing unit) in the time interval following the similar set of conditions. This amount of energy is then an indication of the energy loss. Another way is to train the machine learning module 686 on the historical data in the long-term storage 662 to generate a predictive model per housing unit based on a number of input parameters (e.g. weather conditions, season, occupancy, actual indoor temperature, desired temperature, etc.) generates a value of the energy loss of the housing unit during a future time interval.

[0118] In step 306, the processor 654, in particular the analysis module 684, calculates the required energy per housing unit during a future time interval by using the actual temperature, the desired temperature and the energy loss data. In this step, information regarding the separate heating and cooling system 124 present in the housing unit 122 can also be taken into account. Certain types of systems 124 require more/less energy to get from the actual temperature to the desired temperature. In particular, the efficiency of the heating and cooling system 124 is a relevant parameter and is preferably also available in the housing unit specific data storage 664.

[0119] In step 308, the processor 654, in particular the decision module 688, determines a temperature-time profile of the required temperature of the liquid in the closed circuit 130, in particular on an output side of the collective heat pump 114, as a function of time during the future time interval. based on the calculated required energy. There are a number of relatively simple situations, namely wherein all housing units want heating or cooling (e.g. in winter or summer). In such a situation, the decision module 688 can determine a constant temperature-time profile wherein the specific value of the liquid temperature is directly proportional to the required energy. More complex situations often occur in spring or autumn wherein some of the housing units want heating, some of the housing units want cooling, and some of the housing units want to maintain the status quo. The decision module 688 will then generate a varying temperature-time profile in which warm liquid or cold liquid circulates in the closed circuit 130 in different sequential phases.

[0120] In an advantageous embodiment, the decision module 688 also takes into account the energy loss in the housing units when generating the temperature-time profile. By way of illustration, if it has been determined for a housing unit that in a period of 1 hour the temperature drops from 22 °C to 19 °C (i.e. to the lower limit of permitted temperature limits), then the length of a cooling phase is preferably not higher than 1 hour.

[0121] In step 310, the necessary control signals are generated by the control module 682 and sent to the actors 118 of the collective heat pump 114 such that the temperature of the liquid in the supply section 130A of the closed circuit 130 follows the calculated temperature-time profile.

[0122] In step 312, the central control device 112 sends information about the calculated temperature-time profile to the local control devices 122, e.g. via the communication interface 660. In this way, each of the local control devices 122 obtains information about which energy flow will arrive in the future, i.e. hot or cold liquid. In this way, each local control device 122 can anticipate and, depending on the desired temperature to be achieved, whether or not to circulate liquid from the closed circuit 130 to the housing unit 120. For example, if the resident wants a temperature of 21 °C, while the actual temperature is 23 °C (i.e. there is a need for cooling), and the corresponding local control device 122 is informed about the circulation of warm liquid in the closed circuit 130, a local decision can be made to reduce the flow rate on the supply branch 134 or even stop it completely. In this step, the central control device 112 can also send recommendations or instructions to the local control devices 122 about the extent to which the housing unit 122 needs to be heated/cooled. For example, the recommendation may be to heat the housing unit 122 as much as possible (e.g. to 23 °C) towards the end of the heating phase such that there is sufficient heat to bridge the subsequent cooling phase with an acceptable temperature drop.

[0123] Figure 4 shows a flowchart of a method 400 for controlling the maximum flow rates on the branches 134 of the closed circuit 130 in the heating and cooling system 100. This method 400 generally aims to achieve a proportional distribution of the flow rate in the closed circuit. 130 available across the various housing units 122 such that there is sufficient capacity for heating and/or cooling everywhere.

[0124] In a first step of the method 400, the central control device 112 collects (402) data regarding a maximum energy requirement of each housing unit. Typically this is a set of static data stored in the housing unit specific data storage 664, whereby for each housing unit 122 two numerical values are stored, namely a maximum energy requirement in heating and a maximum energy requirement in cooling. These values are normally determined theoretically depending on the separate heating and cooling system 124 and properties of the housing unit (e.g. the degree of insulation) at a specific ambient temperature (e.g. 35 °C for cooling or -10 °C for heating).

[0125] In step 402, data is also collected regarding the actual flow rate in the closed circuit 130. This can be done, for example, via a flow rate meter present in the closed circuit 130, e.g. on the output side of the collective heat pump 114.

[0126] In step 402, the central control device 112 also collects data regarding the actual temperature in the housing units 120 or in certain spaces thereof. This can be done, for example, via the thermometers 126 present in the housing units 120, whose data are sent by the local control devices 122 to the central control device 112.

[0127] In step 402, data is also collected regarding the temperature desired by an occupant (or user) of the housing units. This data can be obtained in various ways. Classically, the resident has entered a schedule in advance into the local control device 122, which schedule comprises an overview of the desired temperature at any time of the day for each day of the week. This schedule is preferably also stored in the user preferences storage module 666 in the central memory 656. The resident can adjust this schedule via the I/O module 608, after which an update can be made in the user preferences storage module 666. Via the I/O module 608, the resident can also temporarily deviate from the schedule, after which the local control device 122 passes on this deviation to the central control device 112. It is also possible that the machine learning module 686, based on the historically stored desired temperature data, in the long term storage 662, makes a prediction of a resident's desired temperature at the actual time or whether the machine learning module 686 proposes its own weekly schedule. This schedule can then replace the actual schedule, for example after validation by the resident.

[0128] In step 402, the central control device 112 also collects data regarding the actual temperature of the liquid in the closed circuit 130, in particular in its supply section 130A. This can be done via a thermometer 116 present on the output side of the collective heat pump 114 or by checking the actual settings of the relevant actors 118.

[0129] In step 404, the processor 654, in particular the analysis module 684, calculates which housing unit needs heating or cooling. This can be done, for example, by making a comparison of the actual and desired temperature in the housing unit. After determining the status of the housing units (i.e. heating or cooling), the analysis module 684 checks whether collective heat pump 114 is actually in heating or cooling mode (i.e. hot or cold liquid circulating in closed loop 130). The analysis module 684 also calculates, based on the maximum energy requirement, the maximum flow rate required per housing unit. These two quantities are directly proportional to each other as described above. Optionally, the analysis module 684 may also determine the current energy requirement and the therewith corresponding current desired flow rate.

[0130] In step 406, the decision module 688 in the processor 654 uses the status of the housing units 122 and the mode of the collective heat pump 114 to exclude a number of housing units. More specifically, all housing units whose status does not correspond to the mode of the collective heat pump 114 are excluded (e.g. by setting their desired flow rate to value 0). In this way, only housing units remain that want heating (in case the collective heat pump 114 is in heating mode) or housing units that want cooling (in case the collective heat pump 114 is in cooling mode). In the case of a system 100 that only provides heating or cooling, step 406 is superfluous and the method from step 404 proceeds directly to step 408.

[0131] In step 408, the processor 654, in particular the analysis module 684, calculates the total maximum flow rate of the non-excluded housing units, for example by summing the maximum flow rate of each housing unit. This total maximum flow rate is then compared with the actual flow rate in the closed circuit 130. This gives rise to two situations, namely situation 410A wherein the actual flow rate is greater than the total maximum flow rate and situation 410B wherein the actual flow rate is smaller than the total maximum flow rate. The same can be done also for determining a total current desired flow rate.

[0132] This information is then available to the decision module 688, which makes a decision in step 412 about the specific value of the maximum flow rate in each of the supply conduits 134. In situation 410A, the decision is relatively simple. There is sufficient flow rate in the closed circuit 130 such that each housing unit can receive the necessary maximum flow rate. The decision can also be made here to reduce the flow rate in the closed circuit 130. However, this is not always practically possible, e.g. in the case of an air-water heat pump, the flow rate is typically a fixed value. However, in the context of a BEO or KWO field, a variable flow heat pump is often in use. However, in situation 410B there is insufficient flow rate. A possible decision is to increase the flow rate in the closed circuit 130. However, if this is not technically feasible (e.g. with an air-water heat pump), the decision module 688 makes the decision to distribute the available flow proportionally among the housing units. More specifically, this can be done by dividing the necessary maximum flow rate value of each housing unit by the total maximum flow rate and multiplying by the available flow rate.

[0133] Alternatively, it can be checked whether the available flow rate is higher than the total current desired flow rate. If necessary, the maximum flow rate in each supply line 134 can be determined as the current desired flow rate in order to better meet the energy requirements. If not, the decision module 688 takes the decision to distribute the available flow rate evenly among the housing units, for example on the basis of their maximum flow rate or their current desired flow rate.

[0134] In step 414, the necessary control signals are generated by the control module 682 and sent to the actors 118 of the collective heat pump 114 such that, if possible, the flow rate in the closed circuit 130 is adjusted.

[0135] In step 416, the central control device 112 sends information about the calculated maximum flow rates to the local control devices 122 such that a flow rate limiter present on the corresponding supply conduit 134 can be set to the calculated flow rate. Information can also be sent to the excluded housing units such that they can completely shut off their supply.

[0136] The method 400 can optionally also be used to deal with exceptional local situations, in particular in the event that one (or only a few) housing unit(s) unexpectedly has(have) a greater energy need than the theoretical maximum energy requirement. Such a situation can occur after a holiday period when the housing unit has cooled down or warmed up considerably and the residents wish to quickly bring the housing unit to a desired temperature. In such a case, the local control device 122 can signal to the central control device 122 that the maximum flow rate for that housing unit is fully used. The central control device 122 can check (e.g. in step 410A) how much flow is actually surplus in the system 100 and, if necessary, (partly) allocate this flow to the housing unit, e.g. via the signalling in step 416.

[0137] It is furthermore possible to apply methods 300 and 400 simultaneously. For example, when determining the maximum flow rate per housing unit, to use information about the temperature-time profile during the future time interval to regulate the maximum flow rate per housing unit in this future time interval.

[0138] Figure 5 shows a flowchart of a method 500 for regulating a flow rate on a bypass 136 of the closed circuit 130 in the heating and cooling system 100. This method 500 generally has the aim of avoiding too low flow rates over the collective heat pump 114 which, especially with air-water heat pumps, can lead to defects and/or failure of a heat pump.

[0139] In step 502, data is collected regarding the actual flow rate in the closed circuit 130. This can be done, for example, via a flow rate meter present in the closed circuit 130, e.g. on the output side of the collective heat pump 114. Although an air-water heat pump 114 typically delivers a fixed flow rate, the influence of varying pressure on the closed circuit 130 can still lead to a reduced flow rate over the collective heat pump 114. At the same time, historical data about the flow rate in the closed circuit 130 are also collected, e.g. from long-term storage 662. Typically this is data over a recent historical period, e.g. one hour or several hours. The one or more flow rate threshold values of the collective heat pump 114 (or of the individual heat pumps that are part of it) are also retrieved from the collective heat pump operating conditions storage 668.

[0140] In step 504, the processor 654, in particular the analysis module 684, calculates whether there is a trend in the historical flow rate data. More specifically, the analysis module 684 checks whether the flow rate in the closed loop 130 is actually decreasing or whether there has been a declining trend in the recent historical period. In case of an actual downward trend, the method proceeds to step 506 and in case there has been a downward trend (which is no longer downward today) the method proceeds to step 508.

[0141] In step 506, the processor 654, in particular the decision module 688, compares the actual flow rate value in the closed circuit 130 with the one or more threshold values to make a decision on the basis of which flow rate should flow over the bypass 136. More concretely, the lower the flow rate in the closed circuit 130, the higher the flow rate over the bypass 136 must be. In other words, the decision module 688 checks between which of the different flow rate values the flow rate falls and decides on that basis what flow rate is required over the bypass 136.

[0142] In step 508, the processor 654, in particular the decision module 688, determines whether the flow rate in the closed loop is actually stable or increasing. With a stable flow rate, the decision module 688 then decides not to make any adjustment to the flow rate over the bypass 136 and the method possibly returns to step 502. With an increasing flow rate, the decision module compares the actual flow rate value in the closed circuit 130 with the one or several threshold values to make a decision on the basis of which flow rate should flow over the bypass 136. More concretely, the lower the flow rate in the closed circuit 130, the higher the flow rate over the bypass 136 should be. In other words, the decision module 688 checks between which of the different flow rate values the flow rate falls and decides on that basis what flow rate is required over the bypass 136.

[0143] In step 510, the control module 682 generates the necessary control signals and sends them to the actors 118, in particular the flow rate controller 135, of the collective heat pump 114 such that the flow rate over the bypass 136 in the closed circuit 130 is adjusted.

[0144] The method 500 can be further improved, as an alternative to the trend analysis, by using input from the local control devices 122 to check whether the flow rate on the closed circuit 130 will decrease, e.g. if many housing units indicate that they do not require heating/cooling. It is also possible to apply methods 300 and 500 simultaneously. For example, when determining the flow rate over the bypass, to use information about the temperature-time profile during the future time interval to regulate the flow rate over the bypass in this future time interval. Furthermore, input from method 400 can also be used in method 500 (or vice versa) by taking into account any flow rate through bypass 136 when calculating the maximum flow rate on the supply bypass.

[0145] The methods described above can be implemented as computer program instructions. These or parts thereof may be stored locally in the memory 606 of one or more local control devices 122 as well as in the memory 656 of the central control device 112. Alternatively, the computer program instructions or parts thereof may be stored externally and accessible to the central control device 112 and/or one or more local control devices 122 via a respective communication interface.

Claims

1. A control device (112, 122) for controlling a collective heat pump (114) in a heating and/or cooling system (100) for collective residential housing units, which heating and cooling system is provided with:

- the collective heat pump,
- a plurality of residential housing units (120_1, ..., 120_N),
- one closed circuit (130) for circulating a liquid between the collective heat pump and the residential housing units, and
- for each residential housing unit, a supply branch (134_1, ..., 134_N) from the closed circuit to the residential housing unit, each supply branch being provided with an adjustable valve for regulating a flow rate at the supply branch,

wherein the control device is provided with:

- an interface (670) configured to obtain an actual flow rate in the closed circuit and maximum flow rate data of each supply branch, which maximum flow rate data are based on an energy requirement of the corresponding housing unit;
- a decision module (688) configured to determine, based on the data obtained, a maximum flow rate for each residential housing unit; and
- a communications module (660) configured to send maximum flow rate rat data to a respective residential housing unit.

2. The control device according to claim 1, wherein the decision module is configured to:

- determine the total maximum flow rate by taking the sum of all maximum flow rate data;
- if the total maximum flow rate is smaller than the actual flow rate, to determine the maximum flow rate of each residential housing unit as its maximum flow rate data; and
- if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate.

3. The control device according to claim 1, wherein the communications module is further configured to receive data from the residential housing units, and wherein, upon receipt of an activation signal from one of the residential housing units, which activation signal comprises a request for a greater flow rate than the maximum flow rate data of said one of the residential housing units, the decision module is configured to:

- determine the total maximum flow rate by taking the sum of all maximum flow rate data for all residential housing units except said one of the residential housing units with the aforementioned larger flow rate;
- if the total maximum flow rate is less than the actual flow rate, to determine the maximum flow rate of each residential housing unit as its maximum flow rate data for all residential housing units except said one of the residential housing units and to determine the maximum flow rate of said one of the residential housing units as said larger flow rate; and
- if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate.

4. The control device according to any one of the preceding claims, wherein the control device is configured to control a heating and cooling system for collective residential housing units.

5. The control device according to claim 4, wherein the interface is further configured to obtain actual temperature data and desired temperature data from each residential housing unit and temperature data from the liquid on an output side of the collective heat pump,
wherein the control device is further provided with an analysis module (684) configured to:

- based on the actual temperature data and the desired temperature data, to determine a status of each housing unit, wherein the status is one of the following: heating and cooling, and
- to determine a status of collective heat pump, based on the temperature data of the liquid on the output side of the collective heat pump, wherein the status is one of the following: heating and cooling,

wherein the decision module is configured to exclude, based on the status data, any residential housing unit that has a different status than the collective heat pump from determining the maximum flow rate.

6. The control device according to claim 5, wherein the decision module is configured to:

- determine the total maximum flow rate by taking the sum of all maximum flow rate data for the non-excluded residential housing units;
- if the total maximum flow rate is less than the actual flow rate, to determine the maximum flow rate of each non-excluded residential housing unit as its maximum flow rate data; and
- if the total maximum flow rate is greater than the actual flow rate, to determine the maximum flow rate of each non-excluded residential housing unit as a fraction of its maximum flow rate data, wherein the fraction corresponds to a ratio between the actual flow rate and the total maximum flow rate.

7. The control device according to claim 3 or 6, wherein, if the total maximum flow rate is greater than the actual flow rate, the decision module is configured to increase the flow rate in the closed loop

8. The control device according to any one of the preceding claims, wherein the control device is provided with a control module (622, 682) configured to generate control signals for controlling the collective heat pump and for controlling each adjustable valve.

9. A heating and cooling system (100) for collective residential housing units, which heating and cooling system is provided with:

- a collective heat pump (114),
- a plurality of residential housing units (120_1, ..., 120_N), each provided with a heating and cooling system (124) and a local control device (122) for controlling it,
- one closed circuit (130) for circulating a liquid between the collective heat pump and the heating and cooling systems of the housing units,
- a central control device (112) for controlling the collective heat pump,
- for each residential housing unit, a supply branch (134_1, ..., 134_N) from the closed circuit to the residential housing unit, each supply branch being provided with an adjustable valve for regulating a flow rate on the supply branch, the local control device being further configured to control of the controllable valve,

wherein the central control device and each of the local control devices together form a control device according to any one of the preceding claims.

10. The heating and cooling system according to claim 9, wherein the collective heat pump comprises a plurality of air-water heat pumps and/or a plurality of water-water heat pumps, in particular a monobloc heat pump, which are preferably arranged in parallel.

11. The heating and cooling system according to claim 9 or 10, wherein the heating and cooling system is further provided with:

- one or more flow rate meters for determining the actual flow rate on the closed circuit on the output side of the collective heat pump, wherein the central control device is further configured to receive measurements from the one or more flow rate meters, and
- a local flow rate meter on each supply branch for measuring the flow thereon, the local control device being further configured to receive measurements from the local flow rate meter and transmit them to the central control device.

12. A method (400) for controlling a heating and/or cooling system (100) for collective residential housing units (120_1, ..., 120_N), which method comprises the following steps:

- obtaining (402) an actual flow rate in a closed circuit in which liquid circulates between a collective heat pump and the residential housing units, whereby each residential housing unit is connected to the closed circuit via a supply branch;
- obtaining (402) maximum flow rate data on each supply branch, which maximum flow rate data are based on an energy requirement of the corresponding housing unit;
- determining (408) a maximum flow rate for each residential housing unit based on the data obtained; and
- generating (414) control signals for limiting the flow rate on each supply branch in accordance with the determined maximum flow rate.

13. The method according to claim 12, wherein determining the maximum flow rate comprises:

- determining the total maximum flow rate by taking the sum of all maximum flow rate data;
- if the total maximum flow rate is less than the actual flow rate (410A), determining the maximum flow rate of each residential housing unit as its maximum flow rate data; and
- if the total maximum flow rate is greater than the actual flow rate (410B), determining the maximum flow rate of each residential housing unit as a fraction of its maximum flow rate data, the fraction corresponding to a ratio between the actual flow rate and the total maximum flow rate.

14. The method according to claim 13, wherein the method further comprises:

- obtaining (402) actual temperature data and desired temperature data from each residential housing unit and temperature data from the liquid at an output side of the collective heat pump;
- determining (404) a status of each housing unit based on the actual temperature data and the desired temperature data, the status being one of the following: heating and cooling; and
- determining (404) a status of collective heat pump based on the temperature data of the liquid on the output side of the collective heat pump, wherein the status is one of the following: heating and cooling,

wherein the total maximum flow rate is determined by only residential housing units that have the same status as the collective heat pump.

15. The method according to claim 13 or 14, wherein the method further comprises: receiving an activation signal from one of the residential housing units, which activation signal comprises a request for a greater flow rate than the maximum flow rate data of said one of the housing units,

wherein the total maximum flow rate is determined by taking said greater flow rate for said one of the housing units, and
wherein, if the total maximum flow rate is less than the actual flow rate, the maximum flow rate of said one of the housing units is determined as said greater flow rate.

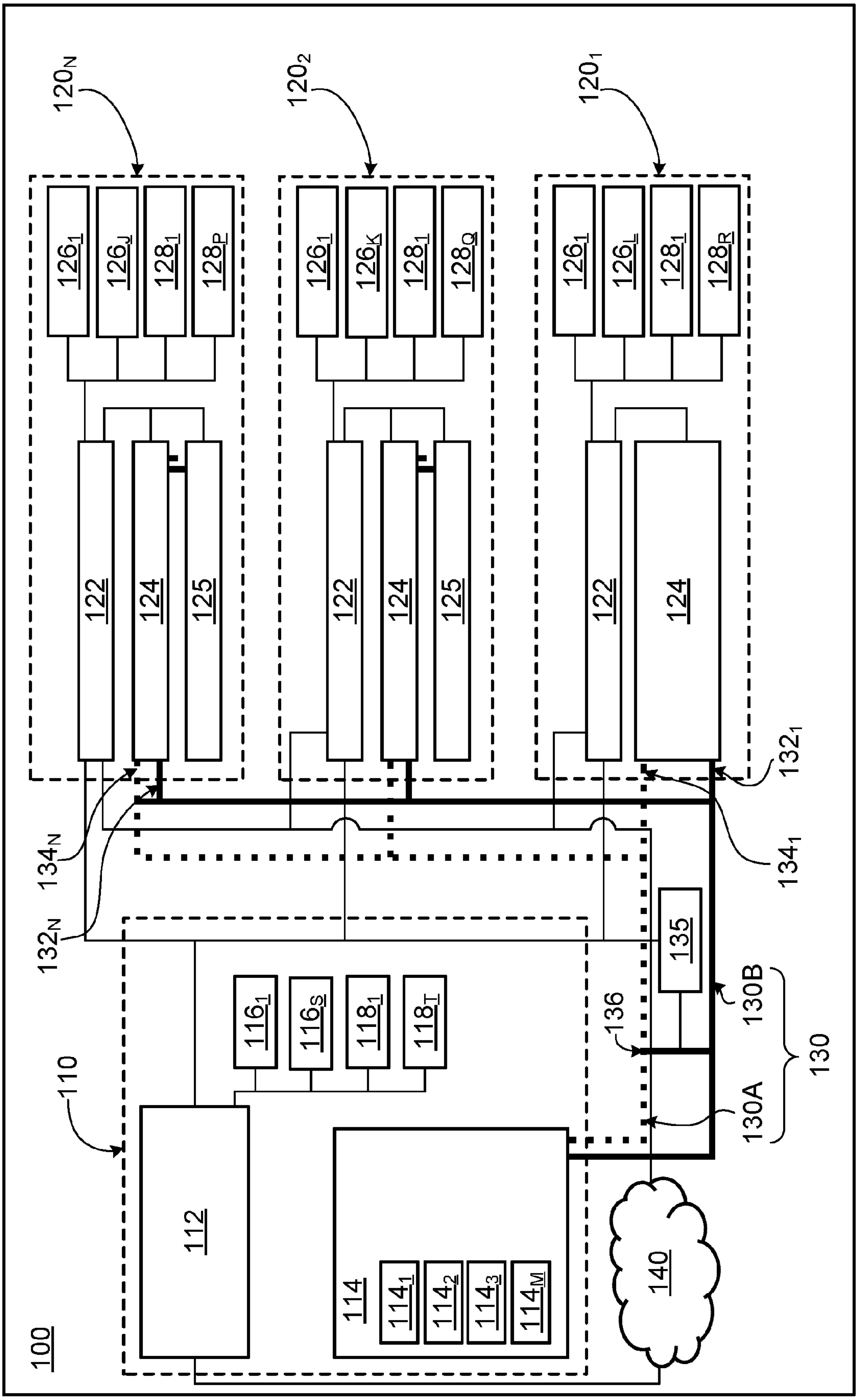
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Fig. 1

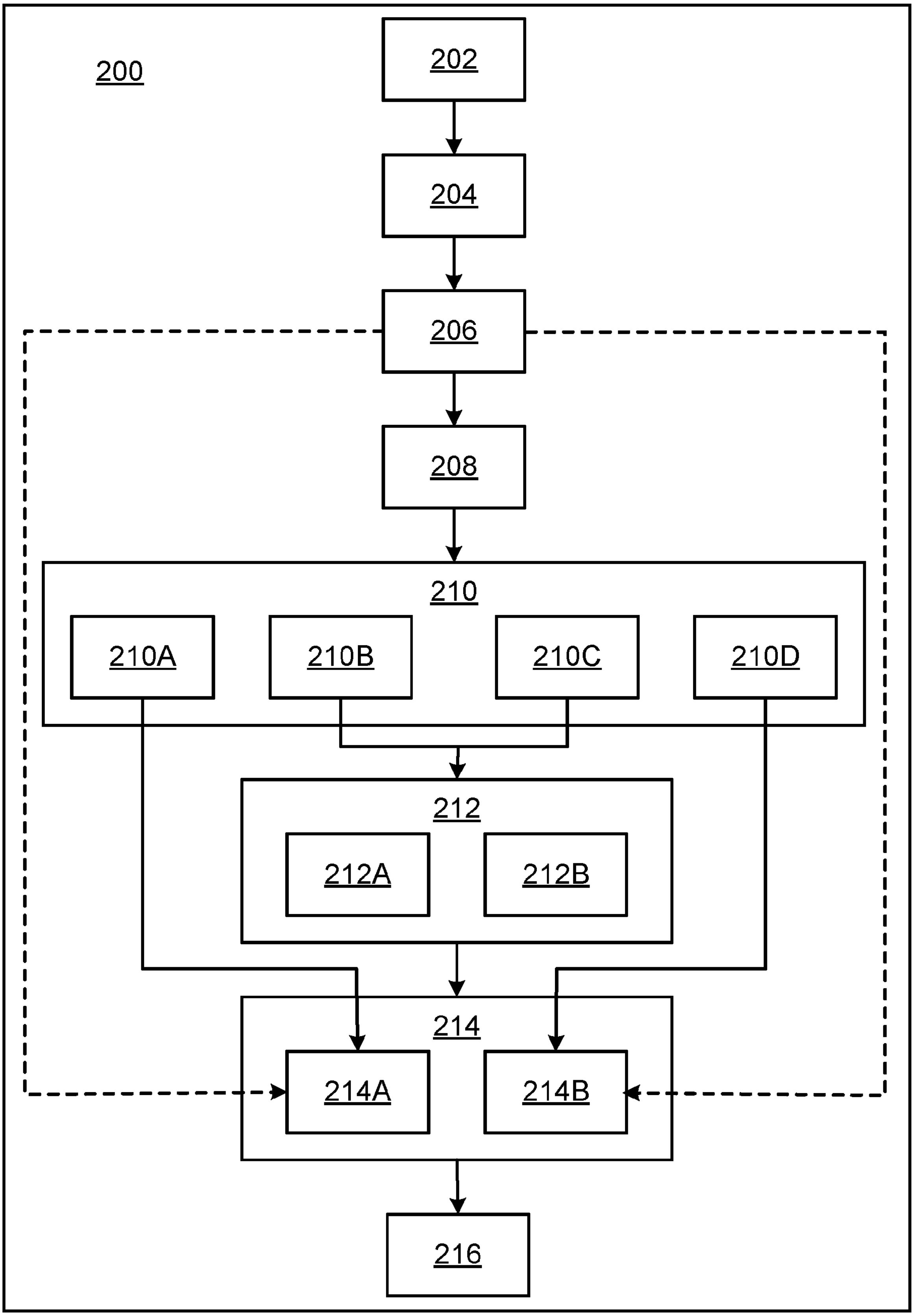
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Fig. 2

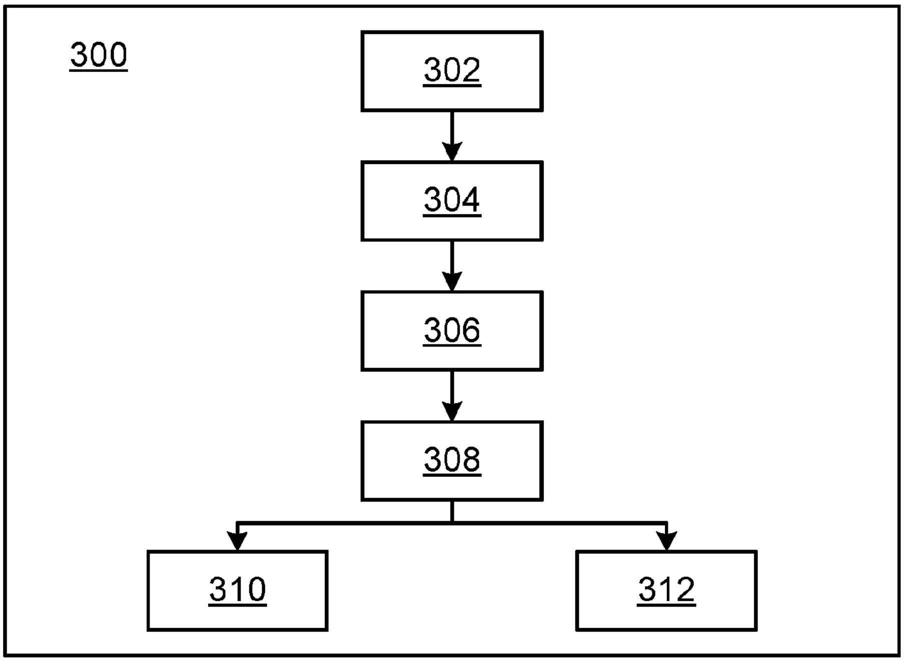
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Fig. 3

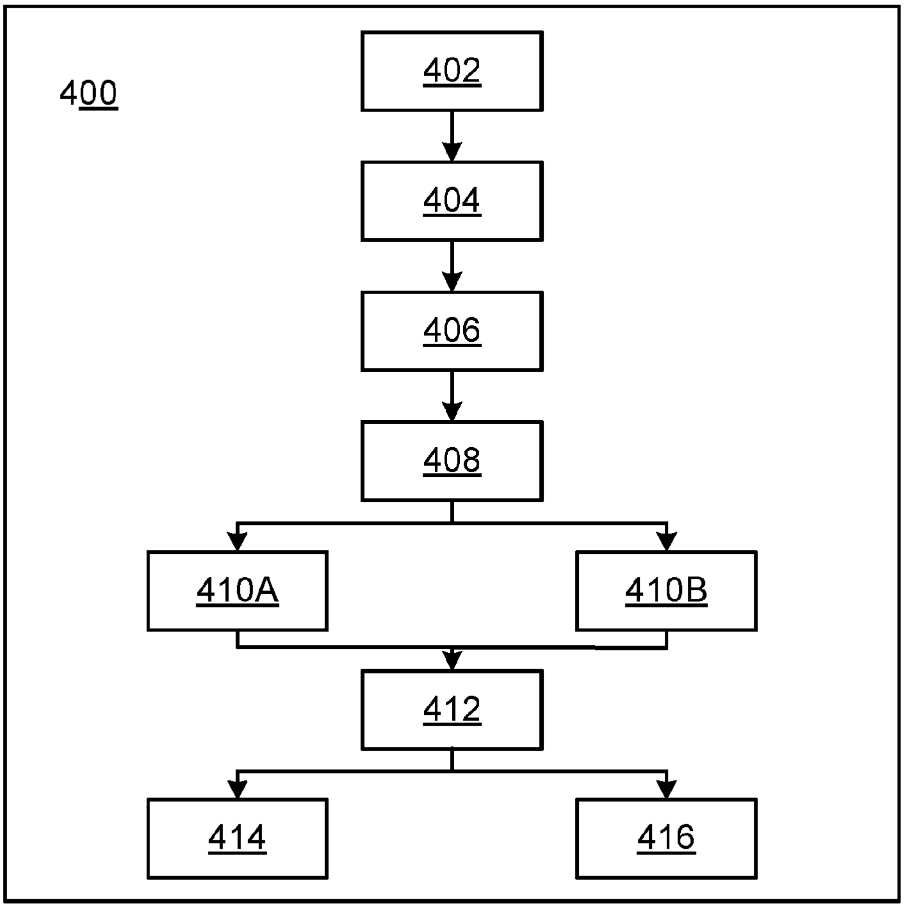
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Fig. 4

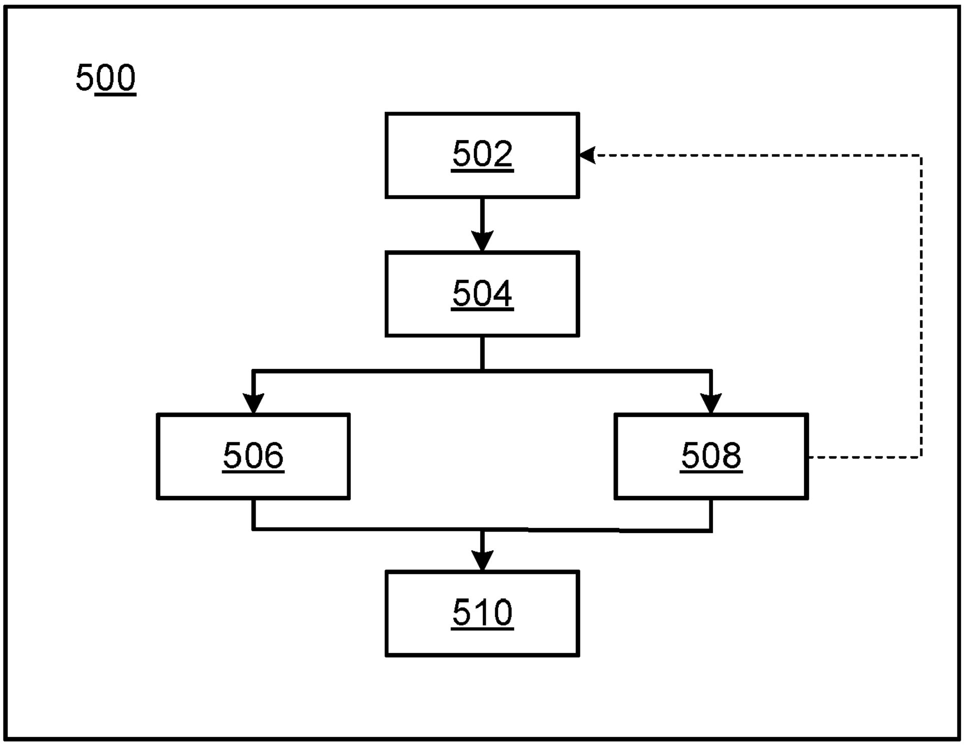

Fig. 5

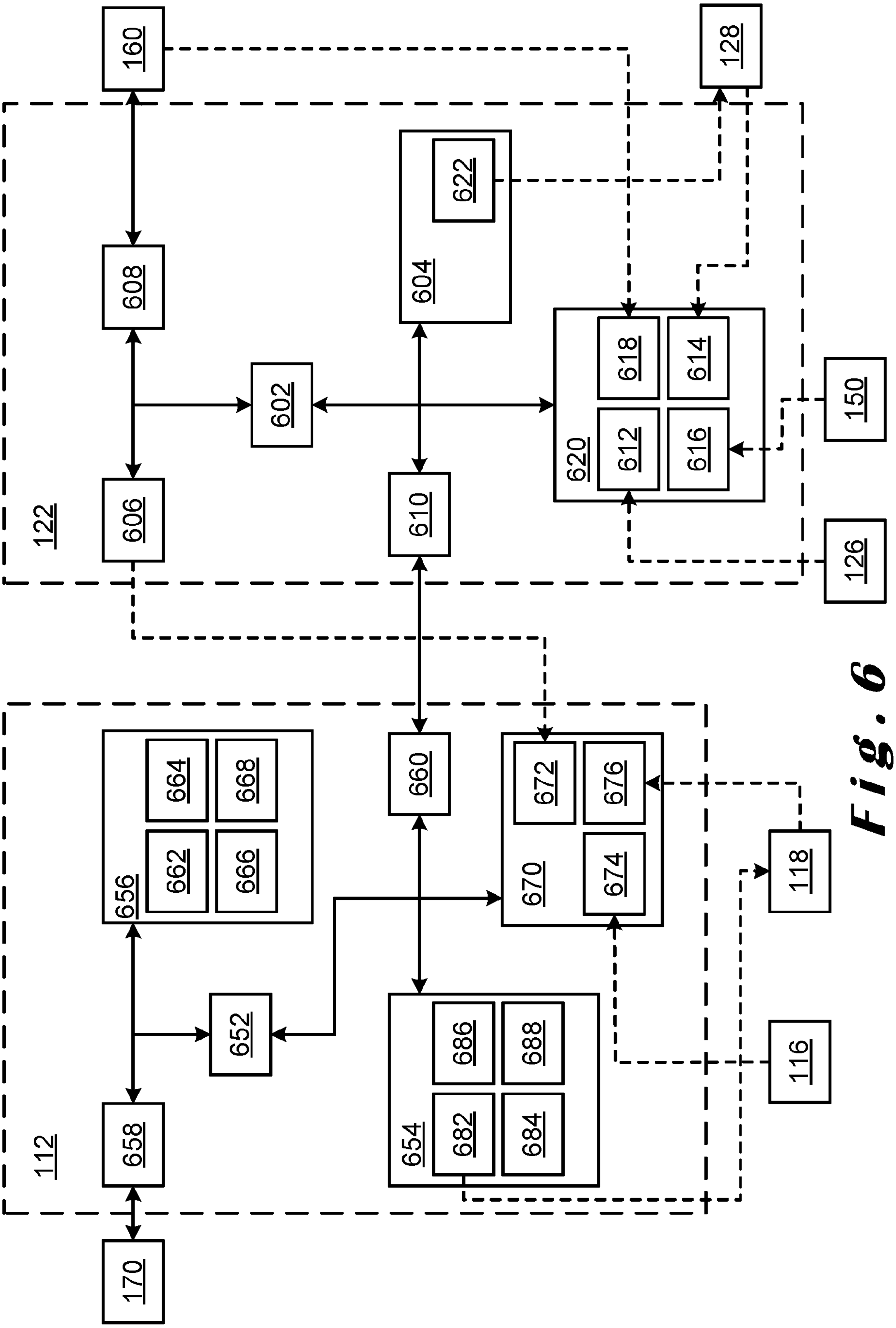
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Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 1008

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1

Place of search	Date of completion of the search	Examiner
Munich	6 November 2023	Mattias Grenbäck

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