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(54) Benævnelse: **APPARAT OG FREMGANGSMÅDE TIL PÅVIRKNING AF TEMPERATUREN I EN BYGNING**

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DESCRIPTION

[0001] The present invention relates to an apparatus for influencing the temperature in a building and a method for operating an apparatus for influencing the temperature in a building comprising a central heat pump unit with a condenser, an evaporator, a compressor, a heat exchanger and an electronic control unit, which operates the flow of a refrigerant within a refrigerant piping for the refrigerant inside of the central heat pump unit, the central heat pump unit being connected to a piping for distributing liquid through the building from the central heat pump unit to at least one indoor unit and back.

[0002] From EP 1 347 253 A1 an apparatus and a method for influencing the temperature in a building is known. The advantage of this apparatus and method is that a refrigerant is replaced by water in a single two pipe ring. This replacement is environmentally friendly, as the refrigerants are causing substantial problems to the atmosphere. Also the safe technical handling of the refrigerants in a building requires substantial efforts during installation and use. The water in the ring pipe is capable to balance different heating and cooling requirements between different rooms in a building at least partially, so that the energy consumption for operating the air condition in a building is reduced. By adding a central heat pump unit to the system the temperature of the water in the ring pipe can be raised or lowered by this heat pump, as it is required. So if there is a general heat energy requirement, this can at least partially be added to the water in the ring pipe by the central heat pump unit, and this works respectively with a general cooling requirement.

[0003] With the known system the individual adjustment of the temperature in a room is achieved by an individual indoor heat pump unit which is installed in each respective room and which is coupled to the ring pipe for extracting water from the ring pipe, adding energy to or taking energy from the water and feeding the water back into the ring pipe thus heating and/or cooling the room installed individually. The indoor heat pump unit, however, requires at least some energy for operation, which reduces the energy efficiency of the whole system, the indoor heat pump unit generates an operational sound in the room by the compressor of the heat pump, and each individual indoor heat pump unit is quite heavy and expensive, so that in a bigger building the weight of the system and its costs are quite substantial. There is also still a refrigerant used in each indoor heat pump unit, which increases the technical complexity of the individual heat pump unit and its service requirement.

[0004] Currently there are also 2 and mainly 3-pipe direct expansion fan coil systems on the market. These systems, however, are operating with a refrigerant in the building pipes. This means that in one pipe there is a hot gas high pressure refrigerant directly from the compressor, in the second pipe there is a liquid refrigerant condensed, and in the third pipe there is a cold gas low pressure coming from the evaporator. The refrigerant used throughout the building is becoming more and more environmentally critical. The high pressure pipes are difficult to mount, there are risks with refrigerant leaking into the building, and repairs are expensive. The indoor units can be used for both, heating and cooling.

[0005] There are also 2 and mainly 4-pipe-systems on the market which deliver warm water with 40° to 55° C, and/or cold water with 5° to 10 °C, warm water returns of 30° - 50° C and cold water returns of 10° - 20° C. These systems are also energetically ineffective as the temperature difference between the temperatures of the liquid in the pipes and the average temperature in the building is quite high and the energy losses are high. The indoor units can be used for both, heating and cooling.

[0006] WO 86/00976 A1 discloses a heat pump unit for influencing the temperature of a building with alternating heating/cooling mode and an additional hot water provision.

[0007] It is the subject of this invention that the disadvantages mentioned above are at least reduced to some extent and advantages are at least enlarged and integrated into a heat pump apparatus and a method with improved efficiency, lower installation and piping costs. This problem is solved by an apparatus, which comprises:

- a central heat pump unit with a warm liquid outlet to a warm liquid piping, a cold liquid outlet to a cold liquid piping and a liquid inlet connected to a return liquid piping (42),
- a condenser as a part of the central heat pump unit being connected with the warm liquid outlet and the liquid inlet,
- an evaporator as a part of the central heat pump unit being connected with the cold liquid outlet and the liquid inlet,
- a compressor as a part of the central heat pump unit to pressurize a refrigerant,
- a heat exchanger as a part of the central heat pump unit to evaporate and heat or to condensate and cool the refrigerant,
- a refrigerant piping as a part of the central heat pump unit being connected with the condenser, the evaporator, the compressor and the heat exchanger, which distributes the refrigerant in the central heat pump unit, and
- at least one indoor unit being connected with the warm liquid outlet by the warm liquid piping, the cold liquid outlet by the cold liquid piping and the liquid inlet by the return liquid piping.

With this apparatus a number of advantages are achieved, especially when the heat exchanger has a high heat transfer coefficient. Each individual indoor unit can be operated as a simple fan unit with a simple heat exchanger. It is not necessary any more to install a heat pump in each single room. So the indoor units are operated with water as an environmentally friendly and preferred example for a liquid only, no refrigerant is used in the rooms or building piping any more. The indoor units are less complex, easy to install and comfortable to use nearly without operational sounds. Due to the reduced complexity the indoor units are substantially cheaper to manufacture and service, which adds up to a substantial saving, the more indoor units are installed in a building.

[0008] All the advantages mentioned are especially achieved by shifting the known ring pipe to a three-pipe system. By the differentiation of the liquid supply to the indoor units between warm and cold liquid both pipings are focused upon their individual function, namely to deliver heating energy by a warm liquid or to collect heat energy from the respective room by a cold liquid. Whatever a user in a room requires, by operating an indoor unit to heat or cool the air in a room liquid - either warm or cold - streams into the indoor unit. In the heat exchanger then either the warmth is taken from the warm liquid or the heat is added to the liquid in the heat exchanger, and the liquid leaves the indoor unit with a different temperature level than it has entered it before, close or even to the local room temperature.

[0009] The return liquid is collected from all single indoor units which are operated in the building in the return liquid piping. In this way the return liquid piping collects all heating and cooling requirements in a building by ending up in a definite temperature of the return liquid at the return liquid inlet. As the individual cooling and heating requirements in each single room of the building are summarized in the return liquid temperature, this temperature is very close to the average temperature in the building, avoiding a need for piping insulation. The amount of energy required to cool and/or heat this return liquid back to a required level is substantially smaller than the energy which would have been required if each room would have been cooled or heated individually and these individual energy requirements were added up in a sum.

[0010] Energy savings can be achieved by the advantageous connection of the three pipes with the condenser and the evaporator on the liquid side and the connection of the refrigerant piping with the condenser and evaporator. An energy excess or an energy requirement of the complete system could be leveled out by the operation of the heat exchanger of the central heat pump unit. If the heat exchanger is cooling down and condensing the refrigerant flowing through it, excessive energy gets lost, and if the heat exchanger evaporates and heats the refrigerant, energy is added to the system over the refrigerant. So the heat exchanger of the central heat pump unit is able to level out a general energy surplus or a general energy requirement from the complete system.

[0011] An additional advantage is achieved by simplifying the indoor units to simple three pipes, passive heat exchangers. To operate the indoor units it is sufficient to open and modulate either a valve in the warm liquid pipe or in the cold liquid pipe, so that the respective liquid can stream as needed into the heat exchanger. By switching a fan on which is also a part of the indoor unit the air in the room is blown through the heat exchanger and thereby cooled or heated. This function of the indoor unit can be automated and easily remotely controlled by respective controls, if required. The indoor unit is also able to keep a preselected temperature in the room.

[0012] An indoor unit can be used as a floor, wall and/or ceiling or suspended heating or cooling unit. Due to the comparably low common favorable temperatures in the three-pipe system the liquid can also be used as a medium for heating or cooling floors, walls and/or ceilings of a building. The heating or cooling of floors, walls and/or ceilings could be reacting slower that the heating or cooling by the indoor units with fans which are heating or cooling the air in a room, however, a very comfortable and constant and even heating or cooling function can be achieved thereby, from the same source.

[0013] The energy consumption of the whole system is reduced, as the COP and EER is up to doubled compared to straight forward heat pump designs. Heat and cold collected in the return liquid is not wasted in the central heat pump unit, it is primarily exchanged between the condenser and the evaporator, so that heat generated in a cooling cycle is transferred to the warm liquid piping, and cold generated in a heating cycle is transferred to the cold liquid piping. The respective energy needed for cooling and heating is kept within the system. As the temperatures of the liquid in the warm liquid piping and the cold liquid piping are differing only by a few degrees from the average temperature in the building and in the return liquid piping, the heat and cold losses within the system are very low, whilst the Carnot factor remains high, which additionally increases the energy efficiency of the system. The indoor units only need electrical power for operating the fan, there is no compressor to be driven any more. So the energy consumption of each indoor unit is also reduced.

[0014] According to a preferred embodiment of the invention, the heat exchanger is in parallel with the condenser or the evaporator. I.e. the heat exchanger, depending on the flow of liquid in the apparatus, is in parallel with the condenser at a certain moment or period of time, while during another moment or period of time, the heat exchanger is in parallel with the evaporator. This is to optimize (minimize) the overall system pressure drop in dual mode operation and not the condensor and the evaporator including the compressor being thermally in balance. As a result of a lower pressure drop, the efficiency of the system will increase. In a situation wherein the compressor is off, the heat exchanger can be in parallel with as well the evaporator as the condenser.

[0015] According to one embodiment of the invention the central heat pump unit comprises an electronic control unit which is connected with at least one pressure sensor comprised in the apparatus, which in use measures a pressure in the refrigerant piping, at least one temperature sensor comprised in the apparatus, which in use measures a temperature in the refrigerant piping, and a number of valves, which are arranged within the refrigerant piping, whose switching/restricting positions in use influence the flow of the refrigerant within the refrigerant piping, wherein the positions of the valves are adjustable by the electronic control unit. By the electronic control unit, its sensors and valves an automated operation of the complete system is possible. The operational settings can be programmed in a suitable computer software. The electronic control system contains the relevant know-how necessary to operate the central heat pump unit and, in addition to that, if required, also for the complete system including the indoor units connected with the central heat pump unit. The energy flow between the condenser, the evaporator, the heat exchanger and the compressor within the central heat pump unit can be controlled by the electronic control unit. The function of the electronic control unit can be extended by using currently measured and/or stored weather information, seasonal information and/or weather forecasts for determining the right strategies for influencing and storing cold and warm liquids and determining their temperature threshold values over one day.

[0016] According to one embodiment of the invention one valves are at least arranged at each of the pipes from the condenser and the evaporator of the refrigerant piping, before the evaporator, before and behind the condenser, and in a pipe back to the compressor, all seen in the feeding direction of the refrigerant, and additional valves can be arranged before and behind the heat exchanger,. These suggested valve positions are advantageous because they allow an efficient control of the flow of the refrigerant within the central heat pump unit. In this document the terms before and behind, if related to a flow of fluid, refer to upstream and downstream, respectively.

[0017] According to one embodiment of the invention pressure sensors are at least attached to the inlet and outlet pipes from the compressor of the refrigerant piping and in the return liquid piping before the circulation pump, all seen in the feeding direction of the return liquid. The information about the pressure status at the suggested locations is helpful to make the right decisions for controlling and steering the function of the central heat pump unit.

[0018] According to one embodiment of the invention temperature sensors are arranged at least before the warm liquid outlet and the cold liquid outlet and behind the return liquid inlet Additional temperature sensors can be arranged in the refrigerant piping before and behind the compressor, in the heat exchanger and in the evaporator, all seen in the feeding direction of the liquid or the refrigerant. The knowledge about the temperatures of the liquid and the refrigerant at the suggested locations helps to make the right decisions about the settings of the valves within the central heat pump unit.

[0019] According to one embodiment of the invention, in use, the electronic control unit controls the feeding capacity of the compressor and/or the feeding capacity of at least one circulation pump being connected with the liquid inlet. By controlling the feeding capacity of the compressor the cycle of refrigerant within the refrigerant piping can be activated, capacity controlled, or stopped, whatever is required in a specific situation. By controlling the feeding capacity of the circulation pump the flow rate of the liquid through the pipings and the pressure of the liquids can be influenced, which is relevant for the proper function of the complete system.

[0020] According to one embodiment of the invention the warm liquid outlet is connected with a warm thermal storage tank, which, in use, feeds warm liquid into the warm liquid piping, and/or the cold liquid outlet is connected with a cold thermal storage tank, which, in use, feeds cold liquid into the cold liquid piping. By integrating thermal storage tanks into the system it is possible to store some warm and cold thermal energy which can be reused as a buffer over e.g. a 24 hour cycle of a day.

[0021] According to one embodiment of the invention the warm thermal storage tank and/or the cold thermal storage tank comprises at least one element with a phase-changing material. By using a phase-changing material the energy storing capacity of the respective thermal storage tank can be enhanced, whilst the temperature remains constant.

[0022] According to one embodiment of the invention there is a shortcut link from the warm thermal storage tank and/or the warm liquid piping to the return liquid piping and a shortcut link from the cold thermal storage tank and/or the cold liquid piping to the return liquid piping, wherein both shortcut links are operable by valves, which are either adjustable due to a differential pressure between the pressure in the warm or cold thermal storage tank and/or the warm or cold liquid piping on the one side and the pressure in the return liquid piping on the other side or adjustable by a controlled drive. Usually the throughput of liquid through the warm liquid pipe system including the warm thermal storage tank is activated if warm liquid streams into one or more indoor units. As long as one or more indoor valves are open, there is a current flow of fresh warm liquid into the warm liquid piping and the warm thermal storage tank. However, as soon as all valves of the indoor units are closed, the flow in the warm liquid piping is stopped. If the temperature of the warm liquid in the warm thermal storage tank and/or the warm liquid piping sinks below a predetermined threshold value, as no further warm liquid is fed to it from the condenser, the temperature can only be raised again if there is a shortcut for the warm liquid by which the valves of the indoor units can be deviated, so that a fresh flow of warm liquid from the condenser is possible even if all valves of the indoor units are closed. This problem is solved by the shortcut. This also applies for the cold liquid respectively as explained for the warm liquid. By using valves as suggested the operation is easy and fail-safe.

[0023] The shortcut link from the cold thermal storage tank and/or the cold liquid piping to the return liquid piping can also be used to extract energy from the cold thermal storage tank and/or the cold liquid piping when the heat exchanger needs a temporary defrosting due to ice build up in humid outside weather conditions. Whilst the defrosting mode is in operation, the condenser is not in use as the refrigerant pressure in the frozen heat exchanger is much lower than in the condenser, due to a pressure regulator valve at the outlet of the condenser. As it may be likely that no indoor unit requires cooling either, the flow in the cool liquid piping may become absent, which would hinder the evaporator to work properly. Then the bypass valve and the cold thermal storage tank and/or the cold liquid piping are activated accordingly in this mode.

[0024] According to one embodiment of the invention the connection of the indoor unit with the warm liquid piping is regulated by a first valve and the connection of the indoor unit with the cold liquid piping is regulated by a second valve, both valves being adjustable or modulated due to the heating or cooling operation of the indoor unit, and wherein the connection of the indoor unit with the return liquid piping can be regulated or modulated by an adjustable maximum flow limiter valve. By the first and second valves the temperature of the liquid flowing through the indoor unit can be adjusted precisely by regulating the portions of cold and warm liquid streaming into the indoor unit with the valves. If a full heating is required, then only the valve of the warm liquid piping is open, and if a full cooling is required, then only the valve of the cold liquid pipe system is open. If no temperature adjustment is needed in the respective room both valves are closed. If a minor temperature adaption in the room is required, then any relative appropriate mixture of throughput of the warm and cold liquid can be selected by the respective operational settings of the respective valves. By the option to regulate the throughput of liquid through the indoor unit generally the function of the indoor unit can better be controlled, and flow related on site commissioning activities are eliminated.

[0025] The indoor unit can comprise an electronic indoor unit control unit which is connected with at least one temperature sensor, which is measuring a temperature of the liquid flowing into the indoor unit, at least one temperature sensor, which is measuring a temperature in the room in which the indoor unit is positioned, and adjustment drives of the first and second valves and optionally the adjustable maximum flow limiter valve, wherein the position of each of the valves is adjustable by the electronic indoor unit control unit. By the electronic indoor unit control unit the function of the indoor unit can be automated. Also the settings can be selected remotely. A preselection of a certain temperature in the room is possible by a user, and the electronic indoor unit control unit then operates the valves according to an appropriate software as it is necessary to achieve and keep the preselected temperature in the respective room.

[0026] According to one embodiment of the invention the electronic indoor unit control unit is connected with the electronic control unit of the central heat pump unit. By the connection of and the communication between the respective control units the operation of both control units can be optimized.

[0027] According to one embodiment of the invention the warm liquid piping and/or cold liquid piping is connected to an external heat exchanger for injecting external heat or cold to the liquid. The external heat exchanger could be connected to a pond, a lake or a river, a sprinkler tank, a swimming pool or a specific water tank or any source of heat by boiler, collector, waste heat or other sources of thermal energy, to use the energy or cold from the water available there, or it could be adapted to use geothermal energy for storing and extracting energy from the ground.

[0028] According to one embodiment of the invention the central heat pump unit is designed as an outdoor unit arranged outside of the building. By this design no space inside of the building gets lost which is usable for other purposes, the heat exchanger can directly blow the heated or cooled air into the surrounding, the operational sound of the central heat pump unit is kept outside of the building and servicing of the unit is easier due to a better accessibility. Even an exchange of the complete unit is possible very quickly, if that should be required. By designing the central heat pump unit as an outdoor unit there is no refrigerant in the building.

[0029] According to one embodiment of the invention the warm, cold and return liquid is water. Water is environmentally friendly and even if a pipe should leak it doesn't cause a danger for persons in the building. It has a high energy loading capacity and it is ideal for being used as a carrier for energy.

[0030] According to one preferred embodiment of the invention the condenser, the evaporator and/or the heat exchanger in the central heat pump unit are connected to the refrigerant piping with 2-way valves, and especially the heat exchanger with two 2-way control valves. The inventive central heat pump unit comprises three heat exchangers: the evaporator, the condenser and the air to refrigerant or refrigerant to air heat exchanger. The heat exchanger - air to refrigerant or refrigerant to air - is not connected to a 4-way valve though being operable in two modes. With the suggested connections of the respective units it is possible to operate the central heat pump unit in heating mode and in cooling mode with 2-way valves, and especially the heat exchanger with only two 2-way control valves. This is a big advantage, because the condenser and the evaporator can be optimized to just one flowing direction of each of the liquid and the refrigerant. The heat exchangers achieve the best function and heat exchange rate, if the flows of the liquid on the one side and the refrigerant on the other side in the heat exchanger are arranged in a counter flow.

[0031] The problem defined in the introduction of this document is also solved by a method, which is characterized by the following elements:

- the liquid leaving the central heat pump unit is distributed to the at least one indoor unit through a warm liquid piping and a cold liquid piping, and the liquid returning to the central heat pump unit from the at least one indoor unit is distributed by a return liquid piping,
- the electronic control unit operates control valves of the refrigerant piping being controlled by the electronic control unit and arranged in the central heat pump unit as follows, if the temperature of the return liquid is
  either above a predetermined threshold value and the return liquid is fed through the evaporator and fed from the evaporator to the cold liquid piping: the refrigerant is being fed through the evaporator and thereafter to the compressor, the heat exchanger and the condenser and/or the liquid receiver,
  or below a predetermined threshold value and the return liquid is fed though the condenser and fed from the condenser to the warm liquid piping: the refrigerant is being fed through the condenser and thereafter to a liquid receiver, to the evaporator and/or the heat exchanger.

[0032] The advantages of the three-pipe system is already explained above, all advantages described also apply for the claimed method.

[0033] By the claimed operation of the electronic control unit in connection with the three-pipe system for the liquid it is possible to run the central heat pump unit with very low / minimal energy losses and a very high to double energetic efficiency. By all feeding options for the refrigerant after it was fed through the condenser or the evaporator the electronic control unit can choose the most energy efficient option or choose a solution where the refrigerant is fed to two or all options if it seems to be appropriate.

[0034] According to one embodiment of the method invention the temperature of the return liquid is kept in a range of plus/minus 8 K around 22° C by the electronic control unit by operating the compressor and/or a circulation pump in addition to the operation of the control valves. If the temperature of the return liquid is kept in the indicated temperature range the whole system can be operated very efficiently. If the temperature of the return liquid gets too high or too low, the electronic control unit can adjust the circulation pump and/or the compressor, so that due to the flow of the liquid through the system the liquid could either be cooled down or heated up, as it may ever be required. However, the main control of the central heat pump unit must not necessarily completely or predominantly be influenced by the average return pipe temperature, also the actual cold and warm liquid temperatures can be integrated into the control strategy, and weather, time, forecasts or historically stored data and set points could be considered by the controls as well.

[0035] According to one embodiment of the method invention the electronic control unit regulates the temperature of the warm liquid at a warm liquid outlet to a value of 30° C plus/minus 8 K and the temperature of the cold liquid at a cold liquid outlet to a value of 15° C plus/minus 8 K by the operation of the valves and the compressor and/or the circulation pump. These temperature ranges have proven to be very energy efficient, and at these temperatures it is possible to provide reasonable reaction times of the indoor units to adapt and regulate the temperature in a room towards a selected temperature. Thermal losses are low to neglectible due to minimum differences with the building temperature.

[0036] According to one embodiment of the method invention the electronic control unit activates the circulation pump and/or the compressor, if the temperature in a warm storage thermal tank and/or the warm liquid piping is dropping below a predetermined threshold value and/or the temperature in a cold storage thermal tank and/or the cold liquid piping is rising over a predetermined threshold value. By the activation of the compressor and/or the circulation pump the temperatures and pressures in these elements can be kept on the desired levels.

[0037] According to one embodiment of the method invention the cold thermal energy contained in the cold thermal storage tank or the warm thermal energy contained in the warm thermal storage tank is added to the liquid flow under peak load conditions of the central heat pump unit. Due to the thermal storage the system is able to store cold and/or warm energy at times when the central heat pump unit is not cooling or heating under peak load conditions. If peak load conditions for cooling or heating appear, the stored thermal capacities can then be activated by allowing cold or warm liquid from the cold or warm thermal storage tank to be added to the liquid flow through the system, so that the technical peak load of the central heat pump unit under the prevailing conditions is boosted by the added thermal energy from the respective thermal storage tank. The peak load conditions in the sense of this claim also apply when the theoretical current peak load operation of the central heat pump unit is shifted to other times of the day and the theoretical peak load is nevertheless reached by replacing thermal capacities missing to the theoretical peak load of the central heat pump unit under its current operation mode by the activation of thermal capacities from the thermal storage tanks. This could be useful to ease the grid load upon an electric network at a specific time, or cost efficiency of the operation can be enhanced. Also, the thermal storage tanks are useful if at a certain moment or period of time, only cooling or only heating operation is required, whilst, at another certain moment or period of time, only heating or only cooling operation is required. The transport of thermal energy by the central heat pump can be transferred in time resulting in passive cooling and/or heating at a later certain moment or period of time. This option improves the sustainability of the system even further.

[0038] It is expressively noted that each of the embodiments mentioned above can be combined with the elements of the independent claims and the other dependent claims, as far as it makes a technical sense.

[0039] Further details of the invention are described in the following example of the invention, which is also described in more detail in the attached drawings. It is shown in

Fig. 1:
a principle drawing of the central heat pump unit,
Fig. 2:
a principle drawing of an indoor unit, and
Fig. 3:
a principle drawing of a complete system.

[0040] In Fig. 1 a principle drawing of a central heat pump unit 2 is shown. The central heat pump unit 2 comprises a condenser 4, an evaporator 6, a compressor 8 and a heat exchanger 10. Albeit of the example shown in Fig. 1 there can be more than just one compressor 8. The liquid which is flowing through the central heat pump unit 2 is guided into the building, in which the temperature shall be influenced, through a warm liquid outlet 12 and a cold liquid outlet 14. The liquid which has been used in indoor units in the building for heating and/or cooling purposes is returning to the central heat pump unit through a liquid inlet 16.

[0041] The condenser 4, the evaporator 6, the compressor 8 and the heat exchanger 10 are connected by a refrigerant piping 18, through which a refrigerant is fed. The moving direction of the refrigerant is indicated by little arrows along the respective pipes. There is also pipe 22 which can be used for shifting the flow of the refrigerant in a desired way. The refrigerant is pumped up to a high pressure gaseous phase in the compressor 8. From there it is guided to the condenser 4. In the condenser 4 the refrigerant condenses, thereby the refrigerant loses energy, which is transferred to the warm liquid which is flowing through the condenser 4 and which is warmed up by the energy added to it. The liquefied refrigerant is then distributed by the refrigerant piping 18 towards the evaporator 6. Before it reaches the evaporator 6 the liquefied refrigerant is fed through the heat exchanger 10, from where it is subcooled, after it has left the heat exchanger 10, and it is fed into a liquid receiver 56 for the liquid refrigerant.

[0042] There are two additional temperature/pressure control pipes 24 connecting two sensor bulbs both at the outlet of the heat exchanger 10 and the outlet of the evaporator 6, to control the evaporation process of the evaporator 6 by an expansion device at the inlet of the evaporator 6, and similar to control the evaporation process of the heat exchanger 10 in case that the heat exchanger 10 is activated as evaporator by the control valves 20e. Their necessity is given by the fact that both evaporation processes are not operated at similar conditions, temperatures and suction pressures.

[0043] In the evaporator 6 the refrigerant gets evaporated and warmed up by the return liquid, which is fed into the central heat pump unit 2 by the circulation pump 26. The return pipe for the return liquid is split up in the central heat pump unit 2 so that the return liquid can either flow to the condenser 4 and/or to the evaporator 6. By that amount of energy by which the refrigerant is evaporated and warmed up in the evaporator 6 the cold liquid flowing through the evaporator 6 at the same time is cooled down respectively.

[0044] In Fig. 1 two circulation pumps 26 are shown just as an example. From the evaporator 6 the refrigerant is guided back through an accumulator 58 to the compressor 8 again. From there the feeding cycle can start again.

[0045] The warm liquid which has been warmed up in the condenser 4 is guided by a respective pipe 38 towards the warm liquid outlet 12. The pipe feeds the warm liquid into a warm thermal storage tank 28, which can be integrated into the central heat pump unit 2 optionally. From the warm thermal storage tank 28 it reaches the warm liquid outlet 12. The cold liquid which has been cooled down in the evaporator 6 is guided by a respective pipe 40 towards the cold liquid outlet 14. The pipe feeds the cold liquid into a cold thermal storage tank 30, which can also be integrated into the central heat pump unit 2 optionally. From there it reaches the cold liquid outlet 14.

[0046] If there is no water flowing through the warm liquid outlet 12, but the content in the warm thermal storage tank 28 and/or the warm liquid piping 38 needs to be increased and exchanged, then the warm liquid can flow through the shortcut link 32 to the return liquid piping 42. If there is no water flowing through the cold liquid outlet 14, but the content in the cold thermal storage tank 30 and/or the cold liquid piping 40 needs to be decreased and exchanged, then the cold liquid can flow through the shortcut link 34 to the return liquid piping 42. The shortcut links can be activated by pressure difference valves 20f and bypass valves 20d. The shortcut links 32, 34 can be arranged in the central heat pump unit 2, but also anywhere in the building, so that the temperature levels of the warm and cold liquids within the building can better be maintained and the reaction times of the indoor units 36 are faster, if preselected temperatures in a room are altered.

[0047] The central heat pump unit comprises an electronic control unit (not shown) which is connected with pressure sensors PT shown in Fig. 1. The pressure sensors PT are measuring a pressure in the refrigerant piping 18 at the respective position. There are also some temperature sensors TT attached to the refrigerant piping 18, which are measuring the temperature of the refrigerant at the specific position in the refrigerant piping 18. The flow of the refrigerant within the refrigerant piping 18 is controlled by a number of valves 20. The switching position of the valves 20 influences the flow of the refrigerant within the refrigerant piping 18. The switching positions of the valves 20 are adjustable by the electronic control unit by controlling adjustment drives of the valves 20, so that the refrigerant piping can be opened or closed at its respective positions, or the throughput of refrigerant can be restricted to a desired extent, whatever is necessary for the proper function of the central heat pump unit 2. By the readings of the pressure sensors PT and the temperature sensors TT the electronic control unit is able to recognize by an appropriate software, how the control valves 20e and valves 20 for regulating the flow of the refrigerant need to be switched and restricted, so that the heating and cooling requirements of the users in the building can be satisfied and the temperatures of the warm and cold liquids flowing through the warm and cold liquid outlets 12, 14 are kept on appropriate levels. The flow of the refrigerant in the refrigerant piping is also influenced by the operation mode of the compressor, which can be modulated or switched on or off by the electronic control unit. If an excess of energy in the central heat pump unit 2 needs to be rejected, then the refrigerant can be guided through the heat exchanger 10 by respective switching positions of the control valves 20e. This can also be made for an injection of energy, if required, by the heat exchanger 10 in a reverse operation.

[0048] By controlling the temperatures of the liquids flowing through the warm liquid outlet 12, the cold liquid out 14 and the liquid inlet 16 the electronic control unit is aware of the temperature levels of the liquids in the respective pipings. By a comparison of the temperature changes of the respective liquids over a certain period the electronic control unit is able to determine, whether there is a general requirement for heating and/or cooling the building. A rise of the temperature of the return liquid indicates a cooling requirement, and a decline of the temperature of the return liquid indicates a heating requirement. The temperature data can be compared to air temperatures outside of the building, the time of the day, the season, weather forecasts and the like. If a higher cooling demand can be expected, the temperature and energy level in the cold thermal storage tank and/or in the cold liquid piping can be lowered in relation to the average value, and if a heating demand is expected then the energy level and the temperature in the warm thermal storage tank and/or in the warm liquid piping can be raised. Due to the energetic connection of the condenser 4 and the evaporator 6 by the refrigerant piping the energy consumed or collected by the respective process of heating or cooling the liquid in the pipings or thermal storage tanks can be transferred to each other, so that a reduction of the energy level and temperature in the cold thermal storage tank and/or in the cold liquid piping leads to an increase of the energy level and temperature in the warm thermal storage tank and/or in the warm liquid piping and vice versa, without needing additional energy from other resources. So a simultaneous thermal heating or cooling or a preloading for these functions builds up energy resources for the inverse process. If at a different time of the day the general heating requirement is shifted towards a cooling requirement, then the preloaded respective energies can again be exchanged between the cold and warm liquid systems, so that again no other energy resources are required to cover that air conditioning demand in the building as long as the saved energy reserves can be used. If beyond this exchange of energy between the warm and cold liquid systems by the central heat pump unit additional energy is required or excessive energy needs to be disposed of, this can be handled to some extent by the heat exchanger 10 and/or the thermal storage tanks 28, 30, so that regular energy resources like electricity, gas, oil or like are only need to a very limited extent or are avoided.

[0049] In Fig. 2 a single indoor unit 36 is shown. The indoor unit 36 shown is connected with the warm liquid outlet 12 of the central heat pump unit 2 by the warm liquid piping 38 and with the cold liquid outlet 14 of the central heat pump unit 2 by the cold liquid piping 40. The indoor unit 36 is also connected with the liquid inlet 16 by the return liquid piping 42. The indoor unit 36 comprises a heat exchanger 56. Depending from the adjustable position of the valves 20a, 20b at the warm and cold liquid pipings 38, 40, liquid with a certain temperature is flowing into the feed pipe 44 to the heat exchanger 54. The fan unit 46 is sucking air from the room through the heat exchanger 54. If the liquid flowing through the feed pipe 44 is warmer than the air flowing through the heat exchanger 54 the air is heated, and if the liquid is colder, then the air is cooled. The throughput of liquid through the indoor unit can additionally be controlled by an adjustable flow limiter valve 20c, which is positioned in the return liquid piping 42.

[0050] The indoor unit 36 may comprise an electronic indoor unit control unit (not shown) which is connected with a temperature sensor TT, which is measuring a temperature of the liquid flowing into the indoor unit 36 through the feed pipe 44, and a temperature sensor TT, which is measuring a temperature in the room in which the indoor unit 36 is positioned. The electronic indoor unit control unit can also be connected with adjustment drives of the first and second valves 20a, 20b at the warm and cold liquid pipings and optionally with a drive of the adjustable flow limiter valve 20c. So the operating position of each of the valves 20a, 20b, 20c is controlled and adjustable by the electronic indoor unit control unit. If a user preselects a desired temperature in the room, and the preselected temperature differs from the temperature measured by the temperature sensor TT in the room, then the electronic indoor unit control unit recognizes whether the room needs to heated or cooled. The electronic indoor unit control unit will then open either the valve 20a to the warm liquid piping 38 or the valve 20b to the cold liquid piping 40, so that the respective liquid flows into the heat exchanger 54. Upon activation of the fan unit 46 the air in the room is then cooled or heated. The respective valve will be kept open or is modulated as long as the electronic indoor unit control unit recognizes a heating or cooling requirement. The electronic indoor unit control unit could also completely or partially open each of both valves to the warm and cold liquid pipings 38, 40 at the same time, so that both liquids get mixed in the feed pipe 44 and a temperature of the liquid is achieved which is between the temperatures of the warm and cold liquid. The electronic indoor unit control unit can be connected by option with the electronic control unit of the central heat pump unit 2. Then the electronic control unit could get an information about cooling or heating requirements in that room, before the temperature of the return liquid changes. If the electronic control unit knows the temperature difference between the preselected temperature and the current temperature, the electronic control unit can also make an estimation about the required amount of heating or cooling and for the time in which the respective function is required. If the electronic control unit gets this information from most or all indoor units 36 installed in the building the electronic control device is able to optimize the operation of the central heat pump unit 2, and to maximize a thermal favorable operation, storage and sustainable operation, to minimize any external energy consumption.

[0051] In Fig. 3 a complete system for a building is shown. The warm liquid flows through the warm liquid piping 38 and the warm liquid outlet 12 into the building. The cold liquid flows through the cold liquid piping 40 and the cold liquid outlet 14 into the building. Optionally there could be an additional warm thermal storage tank 28 and/or a cold thermal storage tank 30 connected to the warm and cold liquid pipings 38, 40. As a further option an external heat exchanger 48 connected to the warm liquid piping 38 and an external heat exchanger 50 connected to the cold liquid piping is shown. Such external heat exchangers 48, 50 could be connected to the ground, it could be earth tanks, water reservoirs, (waste) heat sources or the like. The warm and cold liquids can flow into the four indoor units 36, 36a. The indoor unit 36a is shown as an embedded underfloor heating and/or cooling system, which exchanges energy through the side walls of the pipe and not through a special heat exchanger 54 and a fan unit 46. The liquid which flows into the indoor units 36 flows into the return liquid piping 42, which mounts in the liquid inlet 16 of the central heat pump unit 2. The return liquid piping 42 is connected to an optional passive thermal storage means 52, which could for example be the ceilings, walls or the like of the building using the internal thermal mass of the building.

[0052] The invention has been described by virtue of the example mentioned above. The invention is not limited to this example, an expert could make amendments of the example which deem to be appropriate to him, without leaving the scope of the invention, as defined by the appended claims.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP1347253A1 [0002]
- WO8600976A1 [0006]

Patentkrav

1. Apparat til påvirkning af temperaturen i en bygning, omfattende:

- en centralvarmepumpeenhed (2) med et varmvæskeudløb (12) til et varmvæskerørledning (38), en koldvæskeudløb (14) til en koldvæske-rørledning (40) og et væskeindløb (16) forbundet med en returvæske-rørledning (42),

- en kondensator (4), som er en del af centralvarmepumpeenheden (2), er forbundet med varmvæskeudløbet (12) og væskeindløbet (16),

- en fordamper (6), som er en del af centralvarmepumpeenheden (2), er forbundet med koldvæskeudløbet (14) og væskeindløbet (16),

- en kompressor (8), som er en del af centralvarmepumpeenheden (2), til at tryksætte et kølemiddel,

- en varmeveksler (10), som er en del af centralvarmepumpeenheden (2), til at fordampe og varme eller til at kondensere og køle kølemidlet,

- et kølemiddelrørledning (18), som er en del af centralvarmepumpe-enheden (2), er forbundet med kondensatoren (4), fordamperen (6), kompressoren (8) og varmeveksleren (10), der fordeler kølemidlet i centralvarmepumpeenheden (2), og

- mindst en indvendig enhed (36) er forbundet med varmvæskeudløbet (12) gennem varmvæskerørledningen (38), koldvæskeudløbet (14) gennem koldvæskerørledningen (40) og væskeindløbet (16) gennem tilbageløbsrørledningen (42).

2. Apparat ifølge krav 1, **kendetegnet ved at** varmeveksleren (10) er parallelt med kondensatoren (4) eller fordamperen (6).

3. Apparat ifølge krav 1 eller 2, **kendetegnet ved at** centralvarmepumpeenheden (2) omfatter en elektronisk styreenhed der er forbundet med mindst en tryksensor (PT) omfattet i apparatet, hvilket, i brug, måler et tryk i kølemiddelrørledningen (18), mindst en temperatursensor (TT) omfattet i apparatet, hvilket, i brug, måler en temperatur i kølemiddelrørledningen (18), og et antal ventiler (20), der er anbragt i kølemiddelrørledningen (18), hvis skifte-/begrænsningspositioner i brug påvirker en strøm af kølemidlet inde i kølemiddelrørledningen (18), hvor positionerne af ventilerne (20) er justerbare af den elektroniske styreenhed.

4. Apparat ifølge krav 3, **kendetegnet ved at** ventiler (20) er mindst anbragt ved hver af rørene fra kondensatoren (4) og fordamperen (6) af kølemiddelrørledningen (18), opstrøms og nedstrøms for fordamperen (6), opstrøms og nedstrøms for kondensatoren (4), og i en rørledning (18) tilbage til kompressoren (8), alt set i kølemidlets tilførselsretning, og yderligere styreventiler (20e) kan anbringes opstrøms og nedstrøms varmeveksleren (10), og/eller **ved at** tryksensorerne (PT) er mindst fastgjort til indløbs- og udløbsrørene fra kompressoren (8) af kølemiddelrørledningen (18) og tilbageløbsrørledningen (42) har mindst en tryksensor fastgjort til det opstrøms cirkulationspumpen (26), alt set i tilførselsretningen af returvæsken.

5. Apparat ifølge et hvilket som helst af de foregående krav 2 til 4, **kendetegnet ved at** temperatursensorer (TT) er anbragt mindst opstrøms for varmvæskeudløbet (12) og koldvæskeudløbet (14) og nedstrøms returvæskeindløbet (16), og **ved at** yderligere temperatursensorer (TT) kan anbringes i kølemiddelrørledningen (18) opstrøms og nedstrøms for kompressoren (8), i varmeveksleren (10) og i fordamperen (6), alt set i tilførselsretningen for væsken eller kølemidlet.

6. Apparat ifølge et hvilket som helst af de foregående krav 2 til 5, **kendetegnet ved at**, i brug, styrer den elektroniske styreenhed tilførselskapaciteten af kompressoren (8) og/eller tilførselskapaciteten af mindst en cirkulationspumpe (26) der er forbundet med væskeindløbet (16).

7. Apparat ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** varmvæskeudløbet (12) er forbundet med en varm termisk lagertank (28), hvilket, i brug, tilfører varm væske ind i varmvæskerørledningen (38), og/eller koldvæskeudløbet (14) er forbundet med en kold termisk lagertank (30), hvilket, i brug, tilfører kold væske ind i koldvæskerørledningen (40), og varmvæskelagertanken (28) og/eller koldvæskelagertanken (30) kan omfatte mindst et element med et fase-ændrende materiale, hvor der fortrinsvis er et genvejsforbindelse (32) fra varmvæskelagertanken (28) og/eller varmvæskerør-ledningen (38) til tilbageløbsrørledningen (42) og genvejsforbindelse (34) fra koldvæskelagertanken (30) og/eller koldvæskerørledningen (40) til tilbageløbs-rørledningen (42), hvor begge direkte forbindelser (32, 34) drives af ventiler (20d, 20f), hvilke hver er justerbare på grund af differentialtryk mellem trykket i varm- eller koldvæskelagertanken (28, 30) og/eller varm- eller koldvæskerørled-ningen (40) på den ene side og trykket i tilbageløbsrørledningen (42) på den anden side eller justerbare af et styret drev.

8. Apparat ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** forbindelsen af den indvendige enhed (36) med varmvæskerørledningen (38) er reguleret af en første ventil (20a) og forbindelsen af den indvendige enhed (36) med koldvæskerørledningen (40) er reguleret af en anden ventil (20b), begge ventiler (20a, 20b) er justerbare på grund af opvarmnings- eller kølings-operationen af den indvendige enhed (36), og hvor forbindelsen af den indvendige enhed (36) med tilbageløbsrørledningen (42) kan reguleres af en justerbar maksimumstrømningsbegrænsningsventil (20c).

9. Apparat ifølge krav 8, **kendetegnet ved at** den indvendige enhed (36) omfatter en elektronisk indvendig enhed styreenhed hvilken er forbundet med mindst en temperatursensor (TT), hvilken, i brug, måler en temperatur af væsken der strømmer ind i den indvendige enhed (36), mindst en temperatursensor (TT), hvilken, i brug, måler en temperatur i rummet i hvilket den indvendige enhed (36) er anbragt, og justeringsdrev af de første og anden ventiler (20a, 20b) og eventuelt den justerbare maksimumstrømningsbegrænsningsventil (20c), hvor positionen af hver af (20a, 20b, 20c) er justerbare af den elektroniske indvendige enhed styreenhed, hvor fortrinsvis den elektroniske indvendige enhed styreenhed er forbundet med den elektroniske styreenhed af centralvarmepumpeenheden (2).

10. Apparat ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** varmvæskerørledningen (38) og/eller koldvæskerørledningen (40) er forbundet til en ekstern varmeveksler (48, 50) til indsprøjtning af ekstern varme eller kulde til væsken og/eller **ved at** centralvarmepumpeenheden (2) er udformet som en udendørsenhed anbragt uden for bygningen.

11. Apparat ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** den varme, kolde og returvæske er vand, og/eller **ved at** kondensatoren (4), fordamperen (6) og/eller varmeveksleren (10) i centralvarmepumpeenheden (2) er forbundet til kølemiddelrørledningen (18) med 2-vejs ventiler (20), og især den tredje varmeveksler (10) med to 2-vejs styreventiler (20e).

12. Fremgangsmåde til drift af et apparat til påvirkning af temperaturen i en bygning omfattende en centralvarmepumpeenhed (2) med en kondensator (4), en fordamper (6), en kompressor (8), en varmeveksler (10) og en elektronisk styreenhed, som driver strømmen af et kølemiddel inde i en kølemiddelrørledning (18) for kølemidlet inde i centralvarmepumpeenheden (2), centralvarmepumpe-enheden (2) er forbundet til en rørledning til at fordele væske gennem bygningen fra centralvarmepumpeenheden (2) til mindst en indvendig enhed (36) og retur, **kendetegnet ved at**:

- i en situation hvor opvarmning eller afkøling er påkrævet, forlader væsken centralvarmepumpeenheden (2) fordelt til den mindst ene indvendige enhed (36) gennem en varmvæskerørledning (38) og/eller en koldvæskerørledning (40), og væsken der returnerer til centralvarme-pumpeenheden (2) fra den mindst ene indvendige enhed (36) fordeles derefter af en returvæskerørledning (42),

- den elektroniske styreenhed driver styreventiler (20, 20e) af kølemiddelrørledningen der styres af den elektroniske styreenhed og er anbragt i centralvarmepumpeenheden (2) som følger, hvis temperaturen af returvæsken er

enten a) over en forudbestemt tærskelværdi og returvæsken tilføres gennem fordamperen (6) og tilføres fra fordamperen (6) til koldvæske-rørledningen (40): kølemidlet tilføres gennem fordamperen (6) og derefter til kompressoren (8), varmeveksleren (10) og/eller kondensatoren (4) og væskemodtageren (56), eller b) under en forudbestemt tærskelværdi og returvæsken tilføres gennem kondensatoren (4) og tilføres fra kondensatoren (4) til varmvæskerørledningen (38): kølemidlet tilføres gennem kondensatoren (4) og derefter til en væskemodtager (56), fordamperen (6) og/eller varmeveksleren (10).

13. Fremgangsmåde ifølge krav 12, **kendetegnet ved at** et apparat ifølge et af kravene 1-11 drives, og/eller hvor i en situation a) varmeveksleren (10) er i parallel med kondensatoren (4), og hvor i en situation b) varmeveksleren (10) er i parallel med fordamperen (6).

14. Fremgangsmåde ifølge krav 12 eller 13, **kendetegnet ved at** temperaturen af returvæsken holdes i et område på plus/minus 8 K omkring 22° C ved den elektroniske styreenhed ved drift af kompressoren (8) og/eller cirkulationspumpe (26) udover driften af styreventilerne (20), og/eller **ved at** den elektroniske styreenhed regulerer temperaturen af den varme væske ved varmvæskeudløbet (12) til en værdi på 30°C plus/minus 8 K og temperaturen af den kolde væske ved koldvæskeudløbet (14) til en værdi på 15° C plus/minus 8 K ved driften af ventilerne (20) og kompressoren (8) og/eller cirkulationspumpen (26).

15. Fremgangsmåde ifølge et hvilket som helst af de foregående krav 12 til 14, **kendetegnet ved at** den elektroniske styreenhed aktiverer cirkulationspumpen (26) og/eller kompressoren (8), hvis temperaturen i en varmlagertermisk tank (28) falder under en forudbestemt tærskelværdi og/eller temperaturen i en kold-lagertermisk tank (30) stiger over en forudbestemt tærskelværdi, og/eller **ved at** den koldtermiske energi indeholdt i koldvæskelagertanken (30) eller den varme termiske energi indeholdt i varmvæskelagertanken (28) tilsættes til den flydende strøm under spidsbelastningsbetingelser af centralvarmepumpeenheden (2).

DRAWINGS

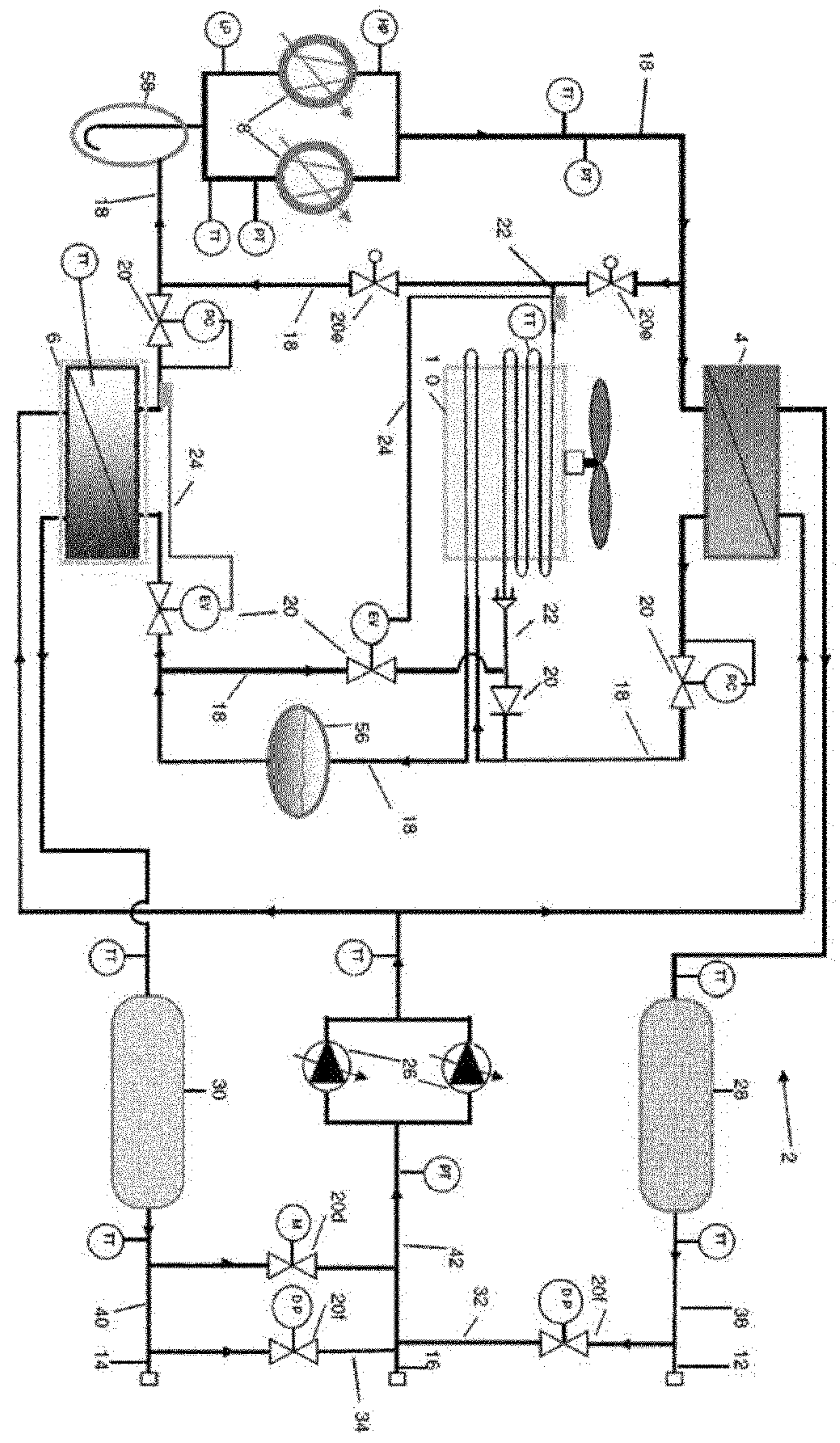

Fig.1

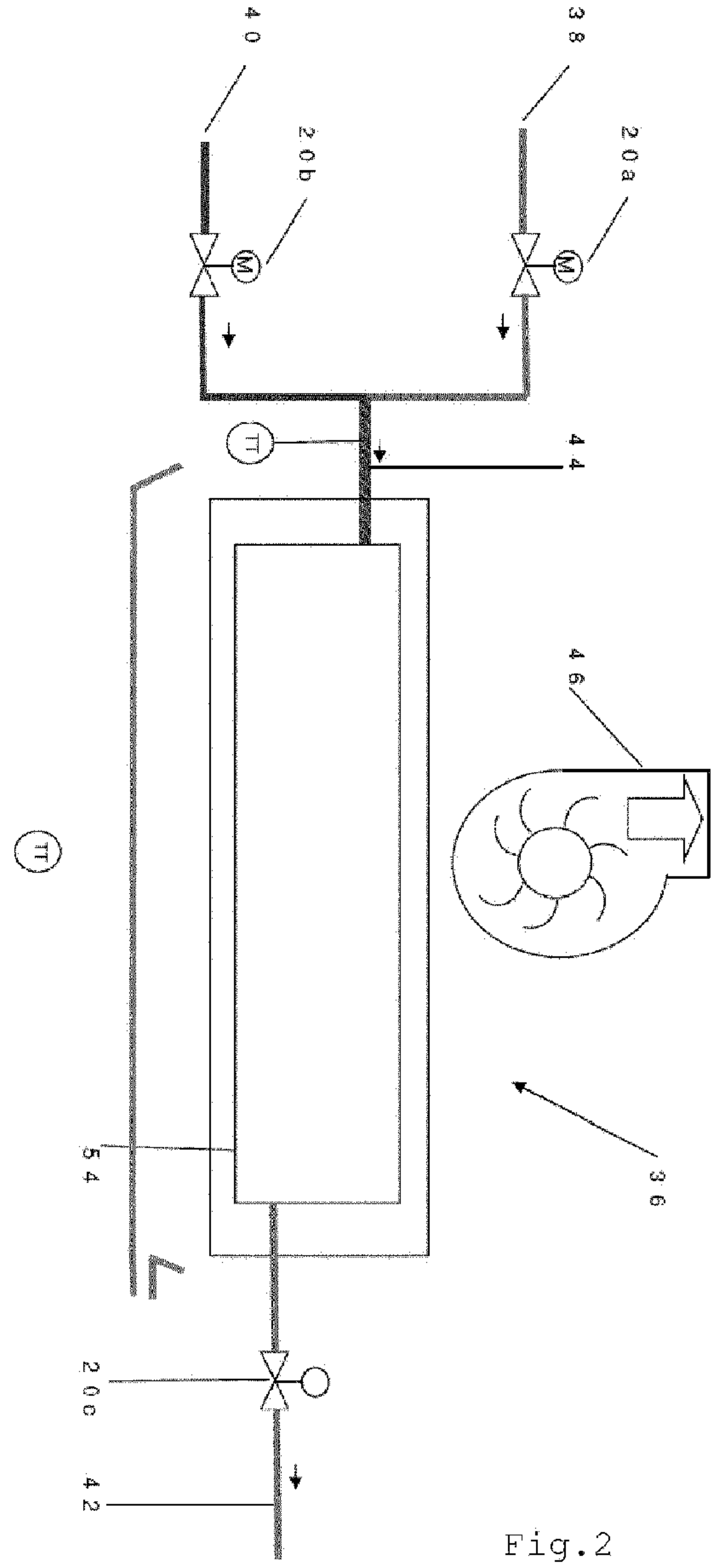

Fig.2

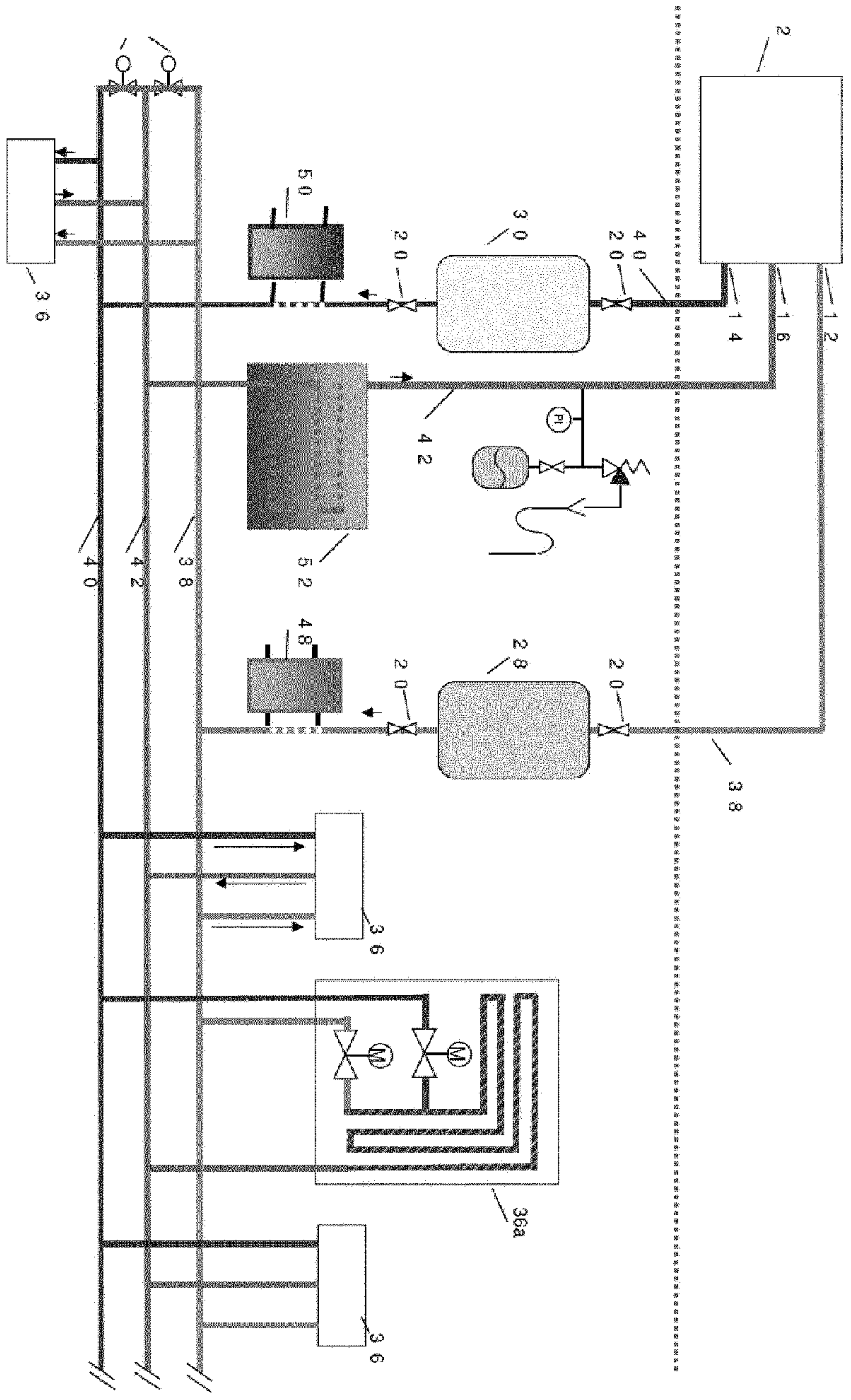

Fig.3