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(54) **Method and device for environment conditioning**

(57) A device for environment control in a space protected against an outside environment is disclosed. The device comprises a circuit with a first circuit portion in which a heat-absorbing medium (204) is arranged to pass through a first heat exchanger (203). A second circuit portion, which is connected in series with the first circuit portion, is arranged to pass the heat-absorbing medium through a second heat exchanger (207). Moreover, a third circuit portion is arranged to transmit heat absorbed by the heat-absorbing medium in the first circuit portion to an electrically driven refrigerating circuit. The second and third circuit portions are arranged in parallel and the device comprises a valve mechanism (209) for guiding the heat-absorbing medium to the second circuit portion when the valve (209) is in a first state and to the third circuit portion when the valve is in a second state.

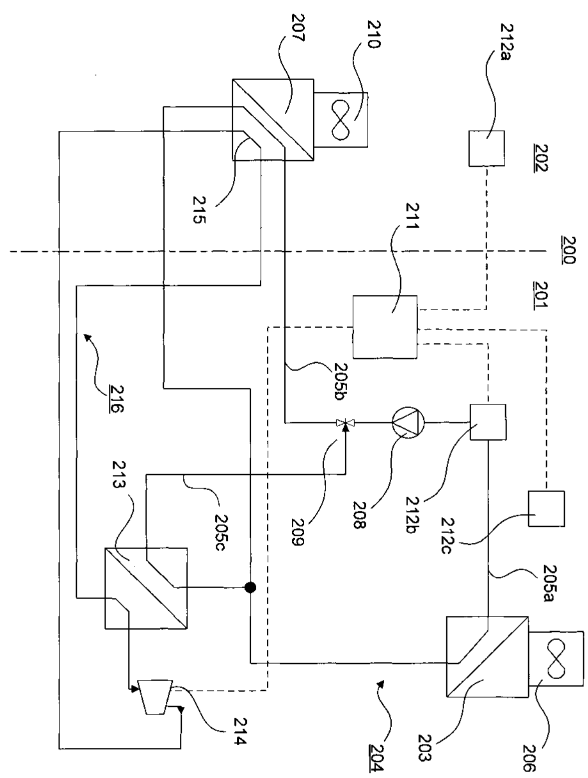

Fig 2

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Description

Technical field

[0001] The present invention relates to a device for temperature and humidity control in a space suitable for accommodating technical equipment, and an associated method for controlling the environment conditions in the space.

Background

[0002] Technical equipment that needs to be spread over a wide area, e.g. electricity distribution plants, railway signal towers, telephone exchanges and radio base stations, is often placed in a shelter or a room in an existing building. The locations of the equipment are often called "sites". Within an electricity supply network, a railway network or a telephone network, there is a great number of sites. E.g. in a mobile telecommunication system, a plurality of base stations, or as called within UTRAN (UMTS Radio Access Network (Universal Mobile Telecommunication System)), Node Bs, has to be distributed over the entire coverage area of the mobile communication system. To be able to cover a country, a mobile telecommunication operator has to distribute maybe a couple of thousands of base stations, and as traffic load in the network increases, more base stations have to be distributed in order to increase the capacity of the mobile communication network.

[0003] As an example, a radio base station within a mobile telecommunication network needs power supply, connection terminals for connecting to the telecommunication network and aerial, matching circuits, backup power supply, etc. All of these pieces of equipment will only work properly within a prescribed temperature range, e.g. between 10 and 50 degrees centigrade. Therefore, an arrangement for keeping the temperature within the shelter or room is also needed. To prevent the temperature from sinking below 10 degrees centigrade, an electric heater is normally used. To prevent the temperature from exceeding more than 50 degrees centigrade, a ventilation or air conditioning system is used. The electric heater and the ventilation or air conditioning system are normally installed in the shelter or room, as would be done in an ordinary building.

[0004] However, during normal operating conditions the temperature rise in e.g. a base station due to the power dissipation in the electronics in the shelter will give rise to greater problems than a possible subnormal inside temperature due to a low outside temperature. In the latter case it is quite simple to raise the inside temperature by means of an ordinary radiator or heater. In the former case it is necessary to install some sort of air conditioning unit or to ventilate the shelter by means of forced ventilation or in some cases self-ventilation.

[0005] In recent years high demands are put on the design of the shelters housing the electronic equipment. For example, a base station within UMTS has to comply with very high demands as to shield against rain and dust. Basically, a space forming a shelter for a base station has to obtain an IP-65 or NEMA/4 rating, which implies that the space is totally protected against dust as well as low pressure jets of water from all directions. Consequently, ventilation by introducing air from outside the shelter is not a suitable approach since it is almost impossible to meet the high protection demands imposed by the IP-65 rating with a direct or indirect communication between the outside atmosphere and the protected environment inside the shelter.

[0006] A general approach to meet the requirements inflicted by the IP-65 rating is to hermetically seal the space where the electronics is residing and use an air conditioning device for cooling the air in the space. Even though this approach shields against the outside environment it is bound with very high operating costs since the air conditioning unit consumes very much power if the outside temperature is higher than the temperature inside the shelter. The costs related to the installation and calibration of the air conditioning unit are also quite high as the air conditioning unit is a separate unit which has to be adapted to the operating conditions inside the shelter.

[0007] Another approach is to use an air-to-air heat exchanger for using the outside air to cool the air in the space. By using an air-to-air heat exchanger it is possible to reduce the operating costs of e.g. a base station. This approach also isolates the inside space from the outside environment but at the same time, as will be explained below, requires that the outside temperature is well below the inside temperature or that the heat exchanger is very large. During summer months or on more southerly latitudes it is common that the outside temperature rises above the highest acceptable inside temperature, or at least that the outside temperature becomes so high that the air-to-air heat exchanger no longer operates effectively.

[0008] A natural approach for cooling or dehumidifying spaces which need to be shielded against an outside environment is then to use a combination of the two technologies above. The air-to-air heat exchanger operates as to lower the temperature inside the shelter as long as the outside temperature is well below the desired inside temperature, whereas the air conditioning unit takes over the cooling operation when the outside temperature becomes too high for the air-to-air heat exchanger to function properly. Even though this approach protects the environment inside the shelter from the outside atmosphere it is not favorable from an economic and installation point of view. It is quite expensive and cumbersome to install and calibrate two different temperature controlling units in the space in the shelter, i.e. the costs related to transportation and installation of the two units will become high since many craftsmen need to be involved in the installation process. Moreover, the multitude of sites together with the physical requirements on the sites generate high costs for maintenance, and the maintenance is often impeded since there is a lot of different equipment placed in different sites.

[0009] The amount of heat (P) transferred from a fluid (gas or liquid) in one chamber of a heat exchanger to the other chamber depends on the coefficient of thermal transmittance (k), the surface of the partition dividing the two chambers (A), and the temperature difference between the fluids in the two chambers (Δt) according to the formula:

$$P = A * \Delta t * k$$

where

$$\frac{1}{k} = \sum \frac{d_i}{\lambda_i} + \sum \frac{1}{\alpha_i}$$

where α is the surface coefficient of heat transfer, d is the thickness of the material in the heat exchanger, and λ is the thermal conductivity of the material.

[0010] This relationship leads to the conclusion that, in order for a heat exchanger to be efficient, the heat exchanger needs to be very large (large area A), operate at great temperature differences between the chambers (large Δt), or use a fluid and a configuration of the heat exchanger which produce a large coefficient of thermal transmittance (k). An air-to-air heat exchanger will become very large since it is hard to achieve a high k-value by using air only as thermal transfer medium. In relation to the discussion above, the air-to-air heat exchanger will become expensive to use since, due to its size, it consumes a lot of valuable space and is difficult to transport to and install in the shelter.

[0011] In an attempt to provide a compact and inexpensive temperature controlling unit which overcomes the drawbacks with self-ventilation or forced ventilation of a protected space, US 5,934,079 proposes a two-stage base station enclosure heat management system. The system comprises an ambient chamber and a closed loop chamber which are thermally interconnected by means of heat pipes and thermoelectric cooler (TEC) elements. By this arrangement it is possible to physically separate the ambient chamber and the closed loop chamber by means of a partition wall. The TEC elements may provide an auxiliary cooling function when the outside temperature becomes too high for the heat pipes to function as heat transfer elements alone. The heat pipes and the TEC elements are arranged in the ambient chamber together with a fan which provides a flow of air from the outside environment past the heat pipes and the TEC-elements in order to cool the air in the closed loop chamber.

[0012] Albeit the invention according to US 5,934,079 solves the problem of isolating the closed loop chamber from the ambient chamber it does not provide an efficient and cheap way of cooling the closed loop chamber since the cooling operation is performed by two independent units that are brought together in order to form a complete cooling unit. No special provisions for cooperation or resource sharing between the two units are provided.

Summary of the invention

[0013] An object of the present invention is to overcome the above described problems of the known technologies in regards to building up and maintaining sites comprising technical equipment. The present invention is based on the understanding that sites comprising technical equipment have a basic physical requirement, and in particular requirements on protection against an outside environment.

[0014] A particular advantage of the present invention is cost, space and maintenance reduction. A further advantage of the invention is reduced energy consumption. Still an advantage is improved robustness, since necessary means for providing temperature control always are adapted to each other.

[0015] A particular feature of the present invention relates to the provision of an apparatus for environment control with a basic configuration that does not differ between sites comprising technical equipment within a network. The network operator will then achieve lower costs and more robust sites.

[0016] The above objects, advantages and features together with numerous other objects, advantages and features, which will become evident from the detailed description below, are obtained according to a first aspect of the present invention by a device for environment control in a space protected against an outside environment, the device comprising:

> a circuit for transportation of a heat-absorbing medium, wherein the circuit comprises
> a first circuit portion in which the heat-absorbing medium is arranged to pass through a first heat exchanger, wherein heat transmits from the protected space to the heat-absorbing medium;
> a second circuit portion which is connected in series with the first circuit portion, in which second circuit the heat absorbing medium is arranged to pass through a second heat exchanger, wherein the heat absorbed by the heat-absorbing medium in the first circuit portion transmits to the environment; and
> a third circuit portion which is connected in series with the first circuit portion, in which third circuit portion the heat absorbed by the heat-absorbing medium in the first circuit portion transmits to a electrically driven refrigerating circuit,

wherein the second and third circuit portion are arranged in parallel, and

wherein the device comprises a valve mechanism for guiding the heat-absorbing medium to the second circuit portion when the valve is in a first state and to the third circuit portion when the valve is in a second state.

[0017] The device according to the present invention may further comprise a temperature sensor which is coupled to a control device, which control device is adapted to shift the valve mechanism from the first state to the second state when the outside temperature rises above a predetermined level, wherein the predetermined temperature level, at which the valve mechanism shifts from the first state to the second state, may be in the range of 8-10 degrees celsius.

[0018] According to the present invention, the electrically driven'refrigerating circuit may comprise a third heat exchanger for receiving heat transferred from the heat-absorbing medium, and a fourth heat exchanger for transferring heat to the environment, which third and fourth heat exchangers are coupled to a compressor as to form a heat pump.

[0019] According to the present invention, the electrically driven refrigerating circuit may comprise a third heat exchanger for receiving heat transferred from the heat-absorbing medium, and fourth heat exchanger for transferring heat to the environment, which third and fourth heat exchangers are coupled to a peltier element as to form a heat pump.

[0020] According to the present invention, the second and fourth heat exchangers may be contiguously arranged.

[0021] According to the present invention, the second and fourth heat exchangers may be arranged in thermal communication in a dual circuit heat exchanger.

[0022] According to the present invention, the heat absorbing medium may be in liquid phase in form of polypropylene glycol.

[0023] According to the present invention, the heat-absorbing medium may be circulated between the communicating heat exchangers by means of a pump.

[0024] According to the present invention, the first, second, third, and fourth heat exchangers, the valve mechanism, and the electrically driven refrigerating circuit may be arranged inside a common housing which is divided into an inside portion communicating with the interior of the shielded space and an outside portion communicating with the exterior of the shielded space.

[0025] According to the present invention, a first fan may be arranged by the first heat exchanger and a second fan may be arranged by the second heat exchanger in order to provide a first air flow, in communication with the protected space, and second air flow, in communication with the outside environment, through the heat exchangers.

[0026] According to the present invention, the speed of the second fan may be operated in order to control the temperature in the protected space.

[0027] The above objects, advantages and features together with numerous other objects, advantages and features, which will become evident from the detailed description below, are obtained according to a second aspect of the present invention by a method for environment control in a space protected against an outside environment, wherein a circuit for transportation of a heat-absorbing medium is provided, the method comprising the steps of:

guiding the heat-absorbing medium through a first circuit portion, in which first circuit portion the heat-absorbing medium passes through a heat exchanger, wherein heat is transferred from the protected space to the heat-absorbing medium;

guiding the heat-absorbing medium through a second circuit portion by means of a valve mechanism when the valve mechanism is in a first state, which second circuit portion is connected in series with the first circuit portion, and in which second circuit portion the heat absorbing medium passes through a second heat exchanger, wherein the heat absorbed by the heat-absorbing medium in the first circuit portion is transferred to the environment; and

guiding the heat-absorbing medium through a third circuit portion by means of a valve mechanism when the valve mechanism is in a second state, which third circuit portion is connected in series with the first circuit portion and in parallel with the second circuit portion, and in which third circuit portion the heat absorbed by the heat-absorbing medium in the first circuit portion is transferred to a electrically driven refrigerating circuit,

[0028] The method according to the invention may further comprise the steps of measuring the temperature outside the protected space and shifting the valve from the first state to the second state when the outside temperature rises above a predetermined level.

[0029] In the method according to the invention, the predetermined temperature level, at which the valve mechanism shifts from the first state to the second state, may be in the range of 8-10 degrees celsius.

[0030] The method according to the invention may further comprise the steps of:

arranging a first fan by the first heat exchanger and a second fan by the second heat exchanger in order to provide a first and second air flow through the heat exchangers.

[0031] In the method according to the invention, the speed of the second fan may be operated in order to control the temperature in the protected space.

[0032] The device according to the invention may be used for environment control in a space protected against an outside environment.

Brief description of the drawings

[0033] Further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description in conjunction with the appended drawings.

Fig 1 illustrates an exterior view of a site equipped with an environment control device according to the present invention.

Fig 2 is an explanatory sketch of the different parts forming the environment control unit according to a first embodiment of the present invention;

Fig 3 is a schematic diagram of an environment control unit according to a preferred embodiment of the present invention illustrating the air flows associated with the environment control of the protected space;

Fig 4 illustrates an example of an arrangement plan for a site shelter according to the present invention; and

Fig 5 is a schematic graph illustrating the typical energy consumption associated with the use of an environment control unit according to a preferred embodiment of the present invention and a prior art air conditioning unit.

Detailed description of the invention

[0034] Fig 1 shows an example of a site 100 according to the present invention comprising a shelter 102 and some external equipment 104. In this particular example, a mobile communication base station site is depicted for illustrative reasons, with an antenna arrangement as external equipment. However, the same reasoning applies for most sites comprising technical equipment, e.g. electricity distribution plants, railway signal towers, telephone exchanges, transmission sites for radio and television broadcasting, private mobile radio network sites, radio repeaters and weather stations. All of these sites generally comprise some form of technical equipment inside a shelter as well as external equipment. As technical equipment normally needs power supply, the site has a connection to a power supply network 106. For control, or input and output of information, the site has a connection to a communication network 108 which in Fig 1 is depicted as a wired connection for illustrative reasons. However, the connection must not be in form of a wire, but may as well be wireless. Given that the shelter normally needs some form of ventilation, an air inlet 110 and an air outlet 112 are provided on a wall of the shelter. In order to provide protection against the outside environment in accordance with the IP-65 rating, the air inlet 110 and the air outlet 112 are covered by a splash shield 113. The splash shield may be in form of a shaped metal plate which constitutes a box with an opening at the bottom towards the ground, and with the top and side portions covered in order to protect the air vent orifices from intrusion of e.g. rain or splashing water. The splash shield may of course be designed in many different ways depending on the protection needed. For example, the splash shield may be in form of an air duct shaped like a labyrinth for preventing water to reach the air vent orifices.

[0035] Fig 2 schematically illustrates the different operating parts of the environment control unit 200 according to a preferred embodiment of the present invention. As can be seen from Fig 2 the environment control unit 200 is divided into a protected space 201 and an outside portion 202. The protected space 201 comprises a first heat exchanger 203 which communicates with the environment inside the protected space 201. The heat exchanger 203 is preferably a two-phase cross-flow heat exchanger, wherein the air in the protected space 201 dissipates excess heat to a heat absorbing medium 204 which is transported through the heat exchanger 203 in a first circuit portion 205a in the environment control unit 200. The first heat exchanger 203 is, however, not necessary a two-phase cross-flow heat exchanger, but may as well be in form of a parallel flow heat-exchanger, counterflow heat exchanger or any other suitable heat exchanger. Moreover, in a preferred embodiment, the heat absorbing medium 204 is polypropylene glycol, but other fluids e.g. glycol, water, water/glycol mixture, ammonia, alcohol, or any other fluid which may receive heat from the protected space 201 may be used as heat absorbing medium 204.

[0036] The air inside the protected space 201 is heated due to the power dissipation in the electronics residing in the space and under certain circumstances the air in the space is not agitated which in turn may lead to temperature differences between different locations in the protected space 201. Normally this phenomenon is observable in form of different temperature layers inside the space, i.e. cold air cumulates along the floor of the space 201 whilst hotter air layers cumulate closer to the ceiling. The lamination of air layers is undesirable since the electronics close to the ceiling may be damaged by overheating or at least exhibit a shorter operating time before failure due to the raised temperature.

[0037] In order to combat the problem with stagnant air, the first heat exchanger 203 is preferably equipped with a fan 206 in order to provide a forced motion of the air inside the protected space. The warm air in the protected space 201 is forced through the heat exchanger 203 by means of the fan 206 and is thereafter returned to the protected space 201. Since the coefficient of thermal transmittance (k) in a heat exchanger normally depends on the air flow through the heat exchanger, the fan 206 also ensures that the heat in the air in the protected space 201 is more effectively transmitted to the heat-absorbing medium 204.

[0038] If the outside temperature is below a predetermined level which according to a preferred embodiment of the present invention is in the range of 8-10 degrees celsius, the heat-absorbing medium 204 is transported via a pump 208 and a valve mechanism 209 to a second heat exchanger 207 being arranged in a second circuit portion 205b in the environment control unit 200. The heat exchangers 203, 207 are normally designed to operate at a specific throughput for optimum performance, wherein the pump 208 is arranged to ensure that a specific volume of the heat-absorbing medium 204 passes through the heat exchangers 203, 207 per unit of time. If the throughput deviates from the specified value, the amount of heat transmitted to or from the heat-absorbing medium 204 is reduced. A static throughput is hence desirable, but the throughput may as well be varied as a method for regulating the heat transmission in the environment control unit 200.

[0039] The valve mechanism 209 guides the heat-absorbing medium 204 from the first heat exchanger 203 to the second heat exchanger 207 when the valve mechanism 209 is in a first state of operation. A return conduit creates a closed transportation loop for the heat-absorbing medium 204 via the first circuit portion 205a and the second circuit portion 205b, wherein the heat-absorbing medium 204 is returned to the first heat exchanger 203 after passing through the second heat exchanger 207. As will be described in more detail below, the valve mechanism 209 may in a preferred embodiment operate in at least two different states.

[0040] The heat absorbed by the heat-absorbing medium 204 in the first heat exchanger 203 is transmitted to the environment in the outer portion 202 of the environment control unit 200 when the heat-absorbing medium passes through the second heat exchanger 207. The second heat exchanger 207 is also preferably in form of a two-phase cross flow heat exchanger, wherein the heat is transmitted to the air in the outer portion 202. As discussed above, in order to increase the efficiency of the heat transfer in the second heat exchanger 207, a second fan 210 is arranged by the second heat exchanger 207 so as to provide a forced motion of the air in the outer portion 202 through the second heat exchanger 207.

[0041] When the temperature in the outer portion 202 rises above approximately 8-10 degrees celsius, the second heat exchanger 207 will no longer be able to transfer heat from the heat-absorbing medium 204 to the air in the outer portion 202 in an efficient way. Instead a control unit 211 which is coupled to a temperature sensor 212a reacts to the rise in the temperature in the outer portion 202 and actuates the valve mechanism 209 to change from the first state of operation to a second state of operation. In the second state of operation, the valve mechanism disconnects the second circuit portion 205b from the first circuit portion 205a and instead connects a third circuit portion 205c to the first circuit portion 205a. According to a preferred embodiment of the present invention, the third circuit portion is coupled to an electrically driven refrigerating circuit comprising an evaporator 213, a compressor 214, and a condenser 215. As a result of the increased temperature in the outer portion, the control unit 211 also activates the refrigerating circuit, wherein the compressor 214 is actuated.

[0042] The heat-absorbing medium 204 is then transferred from the first circuit portion 205a via the pump 208 and the valve mechanism 209 to the third circuit portion 205c, wherein the heat absorbed by the heat-absorbing medium 204 in the first heat exchanger 203 is transmitted via the refrigerating circuit to the environment in the outer portion 202 of the environment control unit 200. A return conduit creates a closed transportation loop for the heat-absorbing medium 204 via the first circuit portion 205a and the third circuit portion 205c, wherein the heat-absorbing medium 204 is returned to the first heat exchanger 203 after passing through the evaporator 213 in the refrigerating circuit. The condenser 215 in the refrigerating circuit may be an independent unit mounted in the outer portion 202 of the environment control unit 200, but is preferably integrated with the second heat exchanger 207 as to form a dual-circuit heat exchanger. In the dual-circuit heat exchanger the heat-absorbing medium 204 is in thermal communication not only with the air in the outer portion 202, but also with a refrigerant 216 in the refrigerating circuit 213-215. An advantage of designing the second heat exchanger 207 as dual-circuit heat exchanger is that the portion of the heat-absorbing medium 204 which is not in motion between the second circuit portion 205b and the first circuit portion 205a when the valve mechanism is in the second state, and the refrigerant 216 when the valve is in the first state of operation respectively, is improving the overall heat transferring capacity of the second heat exchanger 207 due to the increased mass in the second heat exchanger 207.

[0043] It is appreciated in this context that the temperature level, at which the valve mechanism 209 shifts from the first to the second state of operation is not bound to the specified level disclosed above, but depends inter alia on the amount of heat that needs to be transferred from the protected space 201 and the design of the second heat exchanger 207. I.e. if the environment control unit 200 in general and the second heat exchanger 207 in particular is enlarged providing a better cooling efficiency, it will be possible to maintain a satisfactory cooling of the protected space 201 as long as the outside temperature is below the desired temperature in the protected space 201. The valve mechanism 209 may hence not shift state until the outside temperature reaches 25 degrees celsius or even higher. Conversely, if the size of the environment control unit 200 is reduced (e.g. due to space limitations in the shelter), the temperature at which the valve mechanism 209 shifts to the second state of operation has to be decreased. The valve mechanism 209 may hence have to shift state when the outside temperature is well below 8 degrees celsius e.g. 0 degrees celsius. Moreover, the compressor 214 may be replaced by another form of heat extracting device, such as a peltier element, wherein the heat absorbing medium 204 is in thermal contact with one side of the element whilst the other side of the element is in thermal contact with the outer region 202.

[0044] In a preferred embodiment of the present invention, the speed of the fan 210 is operated in order to regulate the temperature in the protected space 201. As mentioned above, the control unit 211 receives data regarding the temperature in the outer region from a first temperature sensor 212a arranged in the outer region 202. In addition to this, the control unit also receives data regarding the temperature of the heat-absorbing medium 204 and the temperature in the protected space from a second 212b and third 212c temperature sensor respectively. When the valve mechanism 209 is in the first state of operation, the inside temperature will be dependent on the speed of the air flow through the heat exchangers 206, 207 that are coupled to the first 205a and the second 205b circuit portions. If the speed of the air flow in the second heat exchanger 207 is changed, the heat transfer from the heat-absorbing medium 204 to the air in the outer portion 202 will also be changed, wherein the temperature difference between the heat-absorbing medium 204 and the air in the protected space 201 changes. Consequently, an increase of the air flow in the second heat exchanger will lower the temperature in the protected space 201. The control unit is therefore adapted to operate the fan 210 in the outer portion 202 on basis of the temperature in the protected space 201.

[0045] When the valve mechanism is in the second state of operation, the second heat exchanger 207 will be part of the refrigerating circuit acting as a condenser 215 for the refrigerant 216. A compressor 214 is normally designed to operate at a specific ambient temperature, i.e. the condenser 215 is designed to transfer heat from the refrigerant 216 to the air in the outer portion 202 within a specific temperature interval in the heat exchanger 207 in order to optimize the performance and the endurance of the compressor 214. By operating the speed of the fan 210 it is possible to control the temperature inside the second heat exchanger 207, wherein the compressor 214 may be operated under optimum conditions. The control unit is therefore also adapted to operate the fan 210 in the outer portion 202 on basis of the temperature in the outer portion.

[0046] As the control unit 211 is connected to the third temperature sensor 212b providing data regarding the temperature of the heat-absorbing medium 204, temperature data related to the heat-absorbing medium 204 may e.g. together with the temperature data related to the air in the outer portion 202 of the environment control unit 200 be used for more precise establishment of an optimum operating point for the compressor 214 as discussed above. The temperature of the heat-absorbing medium 204 may also be used for regulating the speed of the fan 210 so as to make sure that the temperature of the heat-absorbing medium 204 does not drop or rise outside a predetermined temperature range.

[0047] An advantage of using a pump with a static throughput of the heat-absorbing medium is that the second heat exchanger 207 is automatically defrosted in case the temperature in the outer region 202 is very low. As discussed above, the efficiency of the heat exchanger 207 is dependent on the air flow through the heat exchanger 207, wherein a coating of ice inside the heat exchanger 207 will reduce the amount of heat transferred from the protected space 201 to the outer region 202. By measuring the temperature of the heat-absorbing medium 204 and providing a continuous flow of heat-absorbing medium 204 through the heat exchanger, an efficient way of ensuring that no ice layers are formed inside the heat exchanger 207 is provided.

[0048] Fig 3 illustrates the layout of an environment control unit 300 according to a preferred embodiment of the present invention. The first heat exchanger 303 communicates with the environment in the protected space 301 by means of a fan 306 and a first and second vent hole 308, 309. The first arrow 310 illustrates how the air is drawn from the protected space 301 containing e.g. electric equipment through the heat exchanger 303 and the fan 306 and back into the space. Likewise, the outside air is drawn via a third vent hole 311 through the second heat exchanger 307 and the evaporator 315 arranged as a dual-circuit heat exchanger via the fan 310 and back out through a fourth vent hole 312. It is emphasized that the environment control unit 300 is shown in an uninstalled position in Fig 3. When installed, the environment control unit is arranged close to the wall 313 of the shelter, wherein gaskets 314 makes sure that the outer region 302 is separated from the protected space 301. For sake of clarity the pump, valve mechanism, and temperature sensors are not shown in Fig 3 but may be arranged in the protected space 301 as well as in the outer region 302. The splash shield 316 is shown mounted on the outside of the wall 313 and may cover only the lower vent hole 311 or both vent holes 311, 312. In the latter case it is, however, important to separate the air flows in and out of the shelter or else the efficiency of the second heat exchanger 307 will deteriorate due to the feedback of warm air. Since the first heat exchanger 303 normally operates at a temperature lower than the air temperature in the protected space 301, it will act as a dehydrator, wherein moist in the air passing through the heat exchanger 303 will condense on the heat exchanger 303 and flow off the heat exchanger 303 through a small tube 317, which communicates with the outer region via a valve 318 or a pump 319. In case the restrictions regarding the isolation between the protected space 301 and the outer region 302 are lowered, the small tube 317 may directly connect the protected space 301 to the outer region 302.

[0049] Fig 4 shows an example of an arrangement plan for a site shelter using the device shown in Fig 3. The shelter 400 may be built as a small house 401, but may as well be any container. The compact design of the environment control unit 402 provides less stringent demands for space in the house to accommodate the environment control unit 402, thus resulting in more flexible choice of shelter. This will then provide less transports, which may be most beneficiary, since the sites may be located over a wide area, e.g. a country or a whole continent, and not seldom in places difficult to access. To enable entrance to the protected space the house or container 401 is provided with a door 403. The house 401 is also provided with a connection to an AC power supply network 405. The AC power supply network 405 is connected to an AC distribution box 407 preferably located in the housing 401 for supplying 409a the technical equipment with AC power. The AC distribution box may also comprise a converter so as to provide DC power 409b to the technical equipment 410 in the house.The house 401 is also provided with a connection 408 to a communication network. An internal communication network 411 or communication line between different technical equipment in the house is also preferred. In Fig 4 the technical equipment 410 is depicted as one unit, but may of course also be two or more units. The technical equipment 410 preferably has a connection 412 to external equipment such as an aerial in case the house is part of a base station.

[0050] Fig 5 illustrates the typical energy consumption associated with the use of an environment control unit according to a preferred embodiment of the present invention and a prior art air conditioning unit. The X-axis indicates the months of one year while the Y-axis indicates the needed input power to a cooling unit for removing 5 kW of power dissipated into the air in the protected space. The first graph 501 illustrates the input power needed if free air cooling alone is used, i.e. heat in the protected space is removed by means of an arrangement with two heat exchangers corresponding to the first and second heat exchanger 303, 307 and the first and second fan 306, 310. As can be seen the needed input power increases continuously during the springtime and reaches a maximum during the summer months whereupon the power need decreases during the autumn and reaches a minimum during the winter months. The increase in needed power is due to the need for increased air flow through the heat exchangers 303, 307 as the outside temperature increases. The dashed line segment denotes a period of the year when the free air cooling alone does not provide sufficient cooling of the protected space, i.e. the temperature in the protected space rises above the desired temperature level (e.g. 25 degrees celsius). The area under the graph correspond to the yearly power consumption, which in this case with free air cooling alone amount to roughly 3900 kWh.

[0051] The second graph 502 illustrates the yearly power consumption when an air conditioning unit is used for cooling the air in the protected space. The power consumption is static over the year and reaches a total of about 19700 kWh.

[0052] The third graph 503 illustrates the power consumption of an environment control unit according to the present invention. During the early springtime, the power consumption of the environment control unit 200 roughly corresponds to the power consumption associated with free air cooling. Throughout this period the valve mechanism 209 in Fig 2 is in the first state of operation, wherein the fans 206, 210, the heat exchangers 203, 207, and the pump 209 ensures that the temperature in the protected space 201 does not rise above the desired level. During the summer months the valve mechanism 209 is switched to the second state of operation, wherein the refrigerating circuit 213, 214, 215, the fans 206, 210, the first heat exchanger 203, and the pump 209 ensures that the temperature in the protected space 201 does not rise above the desired level. As can be seen from the third graph 503, a considerable power reduction compared to the use of an air conditioning unit is achieved by using the refrigerating circuit 213, 214, 215 only when the temperature in the outer region 202 rises above a certain level (e.g. 8-10 degrees celsius). By using an environment control unit according to the present invention, the yearly power consumption for cooling the protected space amounts to approximately 11000 kWh. Hence a power saving of over 40% is achieved.

[0053] While the present invention has been particularly shown and described with reference to specific embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made thereto, and that other embodiments of the present invention beyond embodiments specifically described herein may be made or practiced without departing from the spirit and scope of the present invention as limited solely by the appended claims.

Claims

1. A device for environment control in a space protected against an outside environment, the device comprising

a circuit for transportation of a heat-absorbing medium, wherein the circuit comprises

a first circuit portion in which the heat-absorbing medium is arranged to pass through a first heat exchanger, wherein heat transmits from the protected space to the heat-absorbing medium;

a second circuit portion which is connected in series with the first circuit portion, in which second circuit the heat absorbing medium is arranged to pass through a second heat exchanger, wherein the heat absorbed by the heat-absorbing medium in the first circuit portion transmits to the environment; and

a third circuit portion which is connected in series with the first circuit portion, in which third circuit portion the heat absorbed by the heat-absorbing medium in the first circuit portion transmits to a electrically driven refrigerating circuit,

wherein the second and third circuit portion are arranged in parallel, and

wherein the device comprises a valve mechanism for guiding the heat-absorbing medium to the second circuit portion when the valve is in a first state and to the third circuit portion when the valve is in a second state.

2. A device according to claim 1, wherein the device comprises a temperature sensor which is coupled to a control device, which control device is adapted to shift the valve mechanism from the first state to the second state when the outside temperature rises above a predetermined level.

3. A device according to claim 2, wherein the predetermined temperature level, at which the valve mechanism shifts from the first state to the second state, is in the range of 8-10 degrees celsius.

4. A device according to any of claims 1-3, wherein the electrically driven refrigerating circuit comprises a third heat exchanger for receiving heat transferred from the heat-absorbing medium, and a fourth heat exchanger for transferring heat to the environment, which third and fourth heat exchangers are coupled to a compressor as to form a heat pump.

5. A device according to any of claims 1-3, wherein the electrically driven refrigerating circuit comprises a third heat exchanger for receiving heat transferred from the heat-absorbing medium, and fourth heat exchanger for transferring heat to the environment, which third and fourth heat exchangers are coupled to a peltier element as to form a heat pump.

6. A device according to any of claims 4 or 5, wherein the second and fourth heat exchangers are contiguously arranged.

7. A device according to claim 6, wherein the second and fourth heat exchangers are arranged in thermal communication in a dual circuit heat exchanger.

8. A device according to any preceding claim, wherein the heat absorbing medium is in liquid phase.

9. A device according to claim 8, wherein the heat-absorbing medium is polypropylene glycol.

10. A device according to any preceding claim, wherein the heat-absorbing medium is circulated between the communicating heat exchangers by means of a pump.

11. A device according to any preceding claim, wherein the first, second, third, and fourth heat exchangers, the valve mechanism, and the electrically driven refrigerating circuit are arranged inside a common housing which is divided into an inside portion communicating with the interior of the shielded space and an outside portion communicating with the exterior of the shielded space.

12. A device according to claim 11, wherein a first fan is arranged by the first heat exchanger and a second fan is arranged by the second heat exchanger in order to provide a first air flow, in communication with the protected space, and second air flow, in communication with the outside environment, through the heat exchangers.

13. A device according to claim 12, wherein the speed of the second fan is operated in order to control the temperature in the protected space.

14. A method for environment control in a space protected against an outside environment, wherein a circuit for transportation of a heat-absorbing medium is provided, the method comprising the steps of:

guiding the heat-absorbing medium through a first circuit portion, in which first circuit portion the heat-absorbing medium passes through a heat exchanger, wherein heat is transferred from the protected space to the heat-absorbing medium;

guiding the heat-absorbing medium through a second circuit portion by means of a valve mechanism when the valve mechanism is in a first state, which second circuit portion is connected in series with the first circuit portion, and in which second circuit portion the heat absorbing medium passes through a second heat exchanger, wherein the heat absorbed by the heat-absorbing medium in the first circuit portion is transferred to the environment; and

guiding the heat-absorbing medium through a third circuit portion by means of a valve mechanism when the valve mechanism is in a second state, which third circuit portion is connected in series with the first circuit portion and in parallel with the second circuit portion, and in which third circuit portion the heat absorbed by the heat-absorbing medium in the first circuit portion is transferred to a electrically driven refrigerating circuit.

15. A method according to claim 14, comprising the steps of measuring the temperature outside the protected space and shifting the valve from the first state to the second state when the outside temperature rises above a predetermined level.

16. A method according to claim 15, wherein the predetermined temperature level, at which the valve mechanism shifts from the first state to the second state, is in the range of 6-12 degrees celsius.

17. A method according to any of claims 14-16, comprising the steps of:

arranging a first fan by the first heat exchanger and a second fan by the second heat exchanger in order to provide a first and second air flow through the heat exchangers.

18. A method according to claim 17, wherein the speed of the second fan is operated in order to control the temperature in the protected space.

19. The use of a device according to any of claims 1-13 for environment control in a space protected against an outside environment.

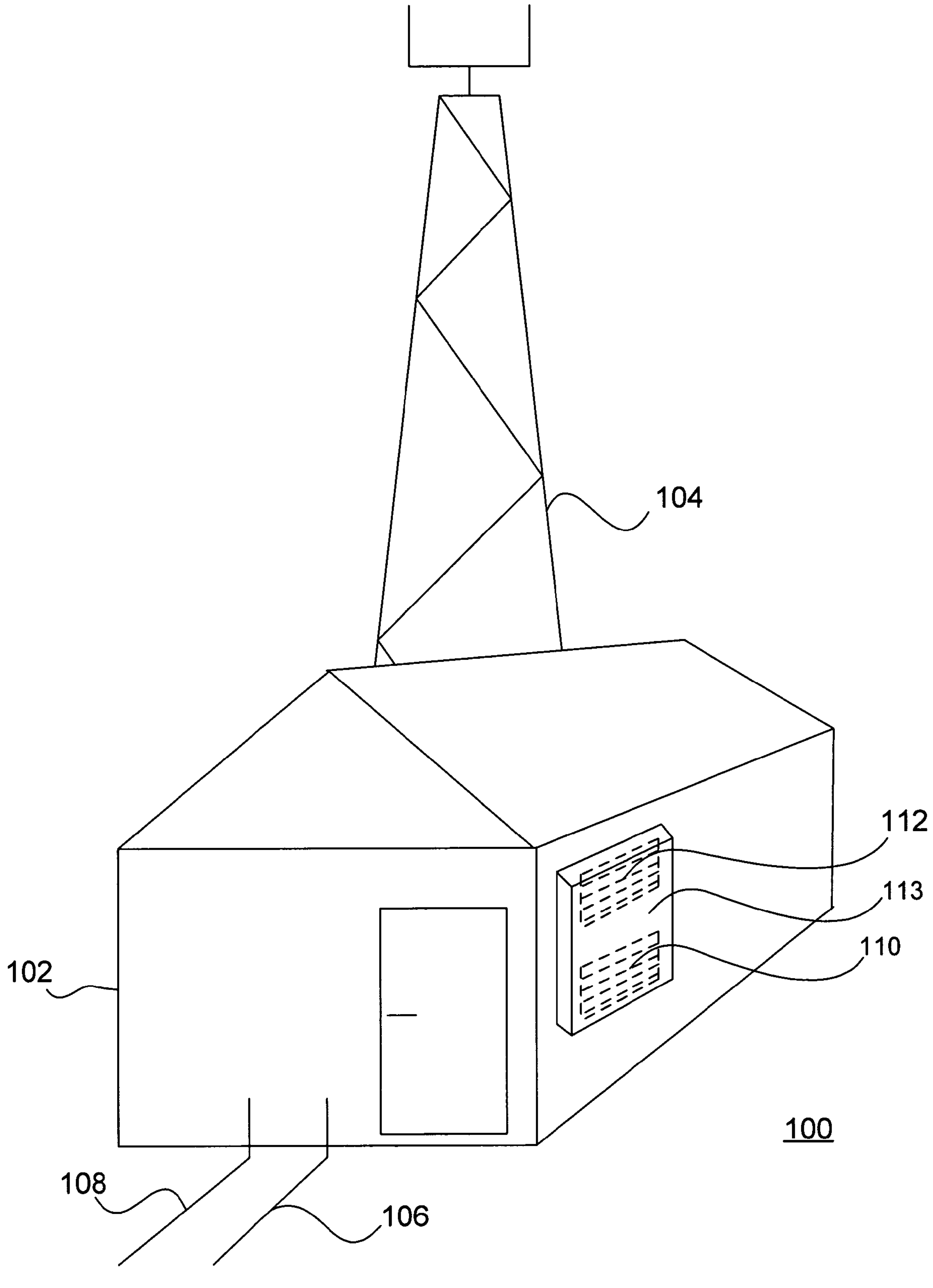

Fig 1

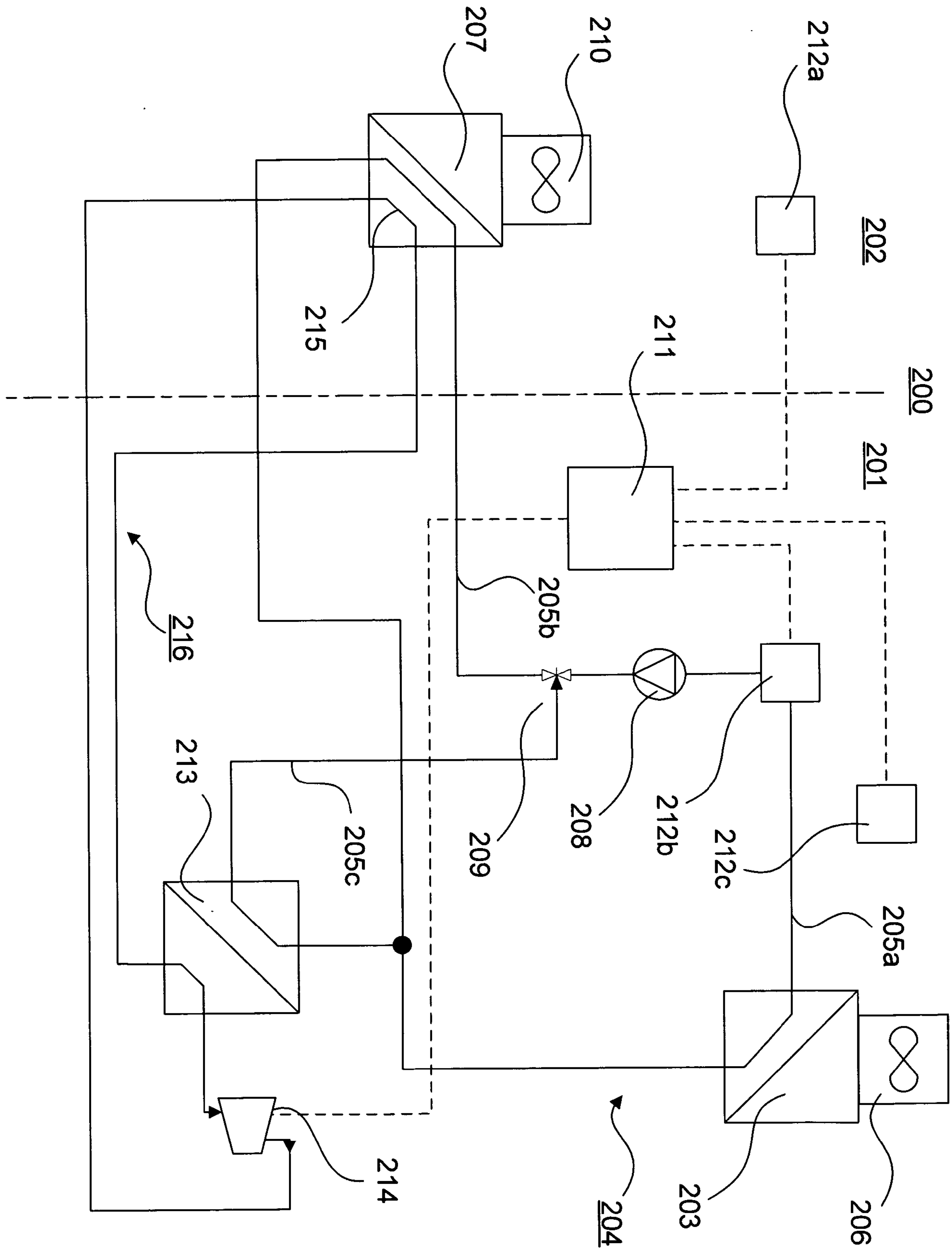
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Fig 2

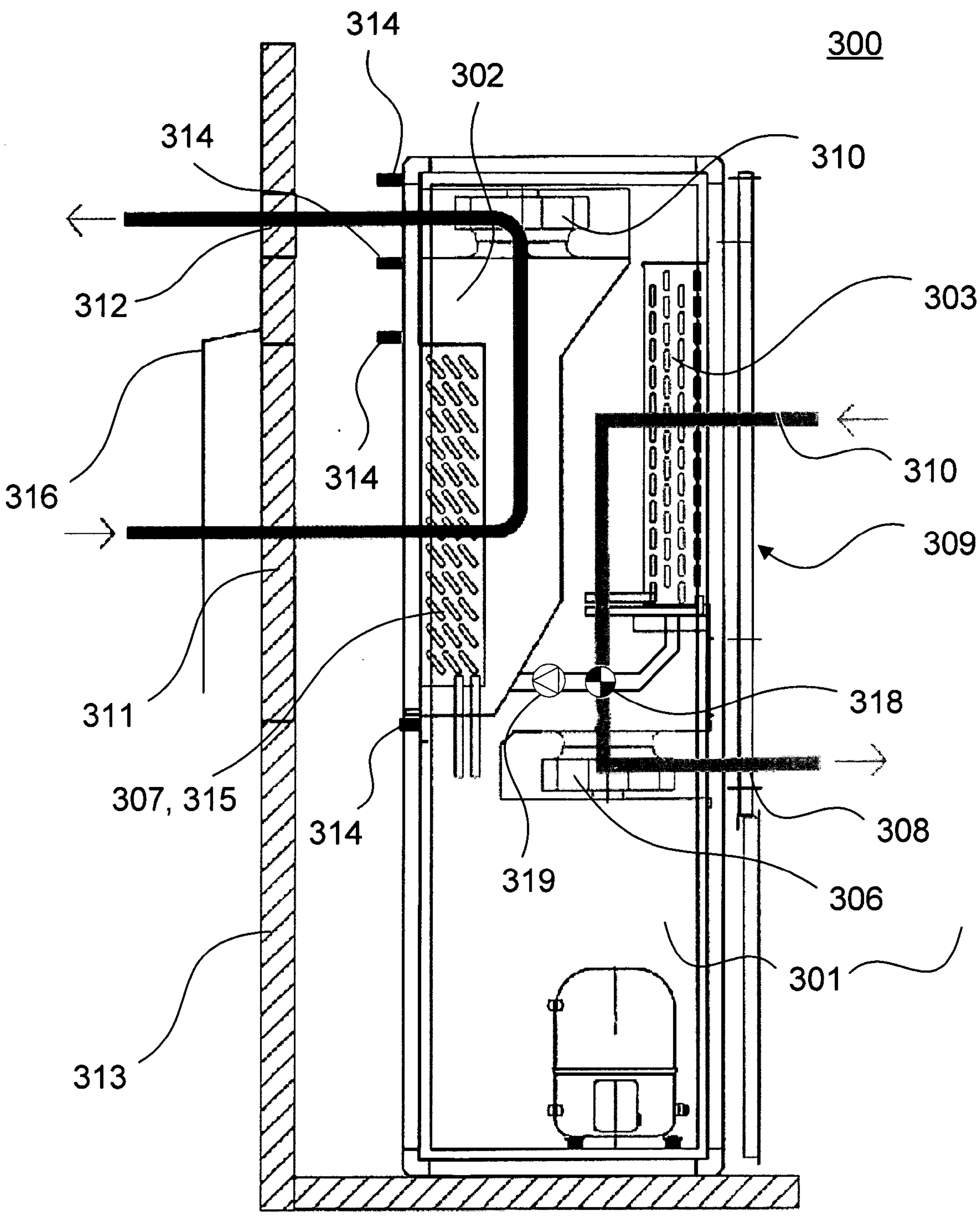

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Fig 3

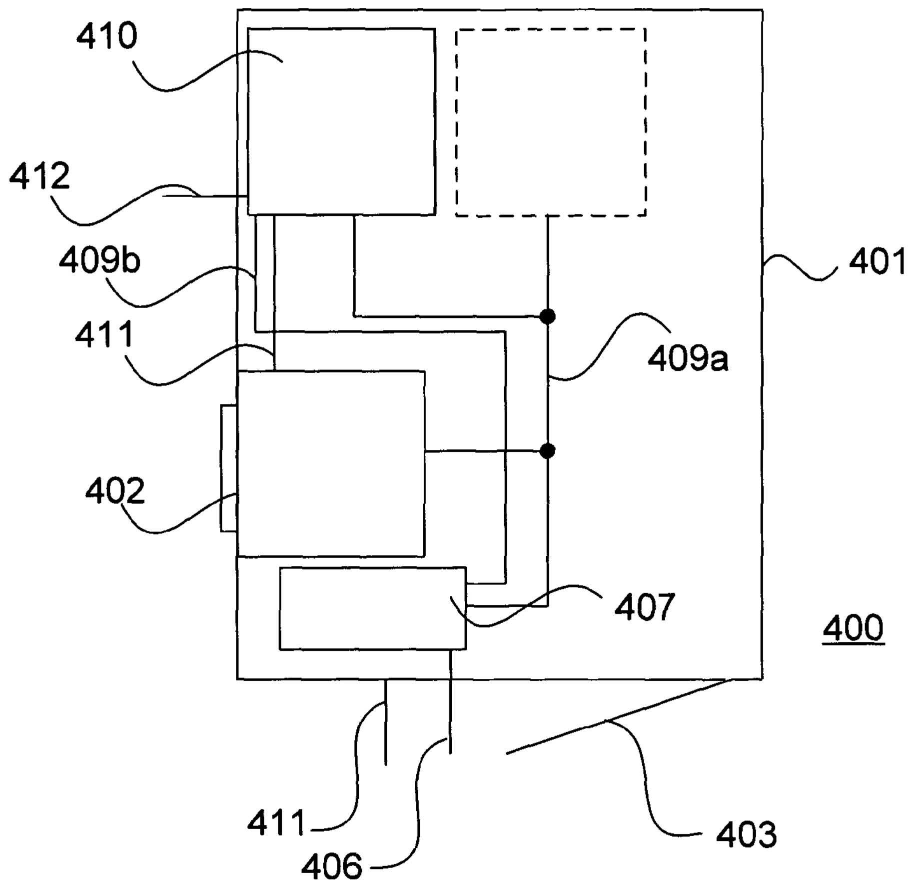

Fig 4

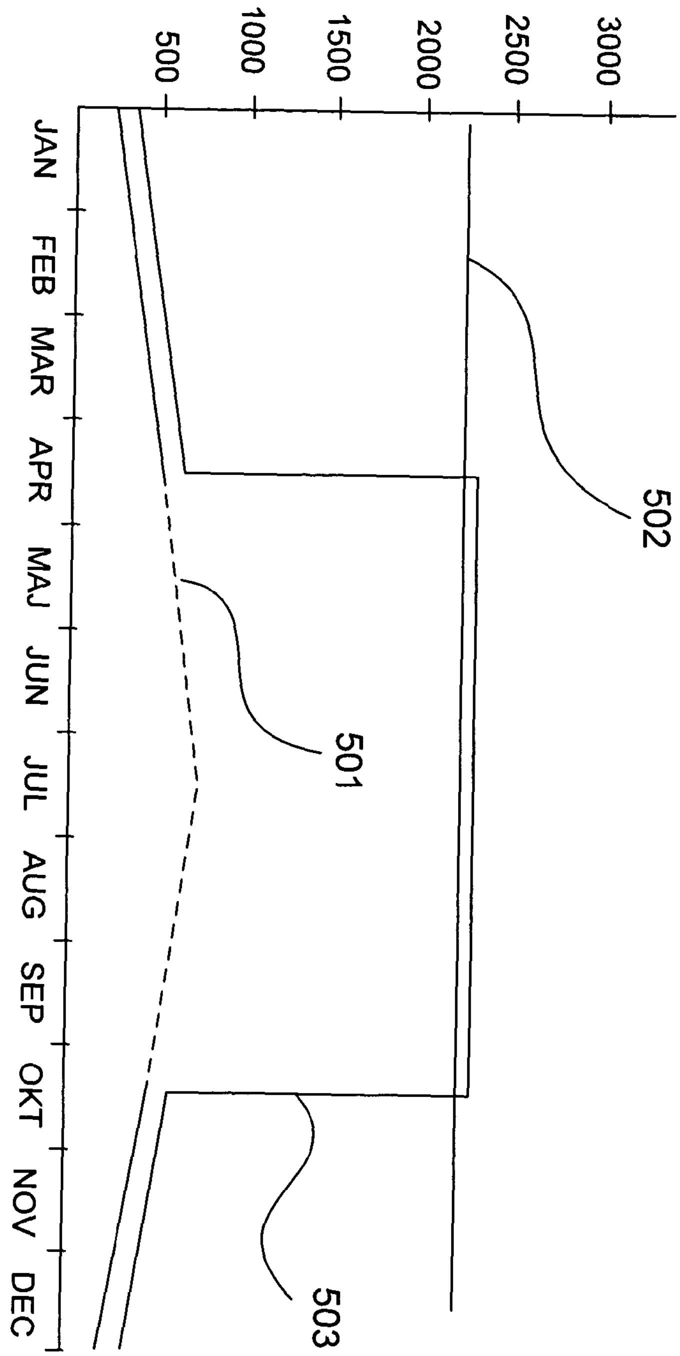
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Fig 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 02 0763

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 February 2004	Gonzalez-Granda, C

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