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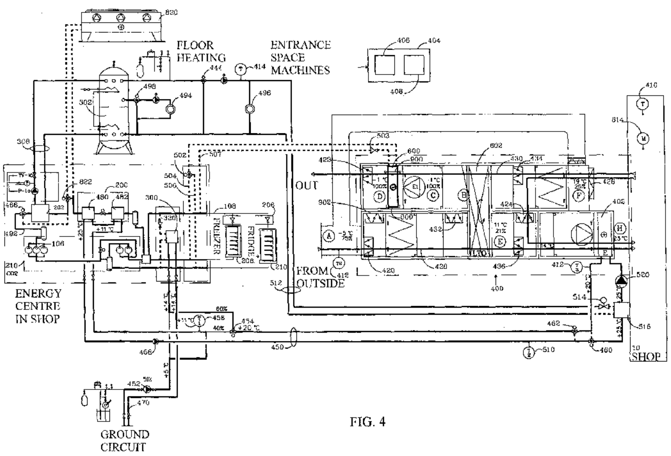


FIG. 4

**(57) Abstract**: The building engineering system comprises heat storage (302); refrigeration equipment (212) having carbon dioxide as refrigerant and comprising an evaporator part (208), expansion valve part (206), compressor part (210) and condenser part (104); a pipe system (108) for circulating the refrigerant in said refrigeration equipment (212); a heat exchanger (202) connected in connection with the condenser part (104) to transfer heat off the refrigeration equipment (212) to the heat storage (302); a supercooler part (200) connected to the pipe system (108) between the condenser part (104) and the expansion valve part (206); an additional heat exchanger part (300) connected to the pipe system (108) in parallel with said evaporator part (208) and expansion valve part (206) to allow heat to be transferred from the additional heat exchanger part (300) to the refrigerant of the pipe system (108) and further to the heat exchanger (202); and a heat transfer pipe system (450) arranged to connect the supercooler part (200), the additional heat exchanger part (300) and at least one other part (204) of the building engineering system to allow heat to be transferred from the supercooler part (200) to the additional heat exchanger part (300) and/or at least one other part (204) of the building engineering system by means of heat carrier in the heat transfer pipe system (450).

# Building engineering system

## Field

**[0001]** The invention relates to a building engineering system comprising refrigeration equipment.

## Background

**[0002]** In a shop, for instance, intense cooling of refrigeration apparatuses is required in summertime. Then, six of the seven compressors in a shop may be in operation at the same time. Intense cooling generates a large amount of heat energy which is not needed anywhere, and it is usually condensed out by a condenser.

**[0003]** In wintertime, by contrast, condensate heat is not sufficient to keep a shop warm but additional heat is required. It is frequently generated by electric resistors, district heat, an oil vessel or a separate ground-source heat pump. Additional heat is stored in a storage accumulator, from which floor heating and air conditioning obtain their heat energy. Of the above-mentioned seven compressors in a shop, maybe only two are required to be in operation in wintertime, which deteriorates their operating efficiency.

**[0004]** There is a plurality of problems in such a solution. Substances detrimental to the climate are used as refrigerants. Further, since cooling of refrigeration equipment is produced with cooling machinery of its own, and other heating with machinery of its own completely separately, the systems waste energy and may harm each other's operation. The compressors are not in efficient operation either. Furthermore, moist condenses on the surface of the refrigeration apparatuses particularly in summertime, which is due to the high level of air humidity and the intense cooling of the refrigeration equipment. Thus, there is a need for achieving a better building engineering system.

## Brief description

**[0005]** An object of the invention is to provide an improved building engineering system. This is achieved by the building engineering system of claim 1.

**[0006]** The invention also relates to a method according to claim 14.

**[0007]** The invention further relates to a control system according to claim 27.

**[0008]** Preferred embodiments of the invention are disclosed in the dependent claims.

**[0009]** Several advantages are achieved by the method according to the invention and. The operation of the refrigeration apparatuses in a building is made more efficient. Further, the operation of the refrigeration apparatuses can be integrated in the heating and air conditioning of the building, so it becomes also possible to boost the efficiency of the energy economy of heating and air conditioning.

**List of figures**

**[0010]** The invention is now described in greater detail in connection with preferred embodiments and with reference to the accompanying drawings, in which

Figure 1 is a block diagram of a heat pump,

Figure 2 shows a part of a building engineering system in which the refrigerant is carbon dioxide,

Figure 3 shows a building engineering system to which additional heat is brought through an additional heat exchanger part,

Figure 4 shows an embodiment where the supercooler of refrigeration equipment is used for heating air arriving in the inside of a building in an air conditioner,

Figure 5 shows an embodiment where an additional heat exchanger part transfers heat from the environment to heat storage,

Figure 6A shows an embodiment where an air-source heat pump transfers heat from the environment to heat storage,

Figure 6B shows the state of air at various points of an air conditioner in humidity/temperature scale.

Figure 7 shows an embodiment where an air-source heat pump transfers heat from the environment to heat storage when the building is in indoor circulation,

Figure 8A shows an embodiment where the indoor air is dried to be drier than the outdoor air,

Figure 8B shows the drying curve for air in humidity/temperature scale,

Figure 9 shows an embodiment where the ice of an air-source heat pump is defrosted,

Figure 10 shows the requirement for heating and cooling energy in different seasons, and

Figure 11 is a flow chart of a method.

## Description of embodiments

**[0011]** The following embodiments are presented by way of example. Even though the description may refer to "a", "one", or "some" embodiment or embodiments at different points, this does not necessarily mean that each such reference refers to the same embodiment or embodiments or that the feature only applies to one embodiment. Individual features of different embodiments may also be combined to make other embodiments possible.

**[0012]** Let us first examine the structure and operating principle of a heat pump by means of Figure 1. A heat pump 110 comprises a closed circuit including an evaporator 100, compressor 106, condenser 104, expansion valve 102 and pipe system 108. Of these, the pipe system 108 is the one to combine the evaporator 100, compressor 106, condenser 104 and expansion valve 102 with each other. Circulating in the closed circuit of the heat pump 110, there is refrigerant that may be carbon dioxide, for example.

**[0013]** The heat pump works like a refrigerator. When refrigerant is evaporated in the evaporator 100, heat is absorbed in it. The refrigerant having absorbed heat may be transferred onwards to a condenser 104 by means of a compressor 106, which is a mechanical compressor. The compressor 106 also raises the pressure of the evaporated refrigerant, whereby also its temperature rises. The refrigerant at a high pressure in the evaporator 104 condenses and the latent heat in it is released to the environment or, via a heat exchanger, to another part of the system. The expansion valve 102 allows condensed refrigerant controllably to return to the evaporator 100, whereby the circulation restarts.

**[0014]** Let us now examine the building engineering system with reference to Figure 2. The refrigerant in refrigeration equipment 212 is carbon dioxide. The refrigeration equipment 212 comprises an evaporator part 208, expansion valve part 206, compressor part 210 and condenser part 104. Further, the refrigeration equipment 212 comprises a pipe system 108 for circulating refrigerant in said refrigeration equipment 212. The evaporator part 208 may comprise one or more evaporators 100. The expansion valve part 206 comprises two compressors 106 in Figure 2. In a general case, there may be one or more compressors 106. One compressor is feasible for instance when both refrigeration apparatuses 214, 216 are alike, such as refrigerators or freezers. Two compressors 106 may be needed when the refrigeration apparatuses 214, 216 are different, such as a refrigerator and a freezer. Then, the freezer 216 may have a separate compressor 106 before the refrigerant pipes of the refrigerator 214 and freezer 216 join and feed refrigerant to a common compressor. In general terms, the refrigeration equipment 212 may correspond to, for example, a cooler, coolers, a refrigerator, refrigerators, a freezer, freezers or a combination of these.

**[0015]** Further, the building engineering system comprises a heat exchanger 202 which allows heat to be transferred off the refrigeration equipment 212 to other parts of the system. In the heat exchanger 202, the heat absorbed by carbon dioxide is transferred by conduction, for instance, to be carried by a first heat carrier in a pipe system 308. The first heat carrier may be different from the refrigerant, and the first heat carrier comprises for instance water or it may be water. In the conduction taking place in the heat exchanger 202, a part of the pipe system 108 is in contact with the pipe system 308 transferring the first heat carrier, whereby the heat is transferred from carbon dioxide to the first heat carrier through the pipe systems 108, 308. However, the heat carrier and the refrigerant are not mixed together.

**[0016]** The building engineering system further comprises a supercooler part 200 connected to the pipe system 108 between the condenser part 104 and the expansion valve part 206. The supercooler part 200 may comprise one or more supercoolers. In a supercooler, the pipe system 108 carrying the refrigerant, and a heat transfer pipe system 220 carrying the heat carrier may be in contact with each other, whereby the heat may be transferred by conduction from the refrigerant to the heat carrier through the pipe materials. A second heat carrier flowing in the heat transfer pipe system 220 may be, for instance, a mixture of water and alcohol, or the like. The heat carrier in the heat transfer pipe system 220 carries the heat to at least one other desired destination 204, which may be a part of the building engineering system. Thus, the refrigerant going to one or more refrigeration machines 214, 216 cools off, which improves the efficiency of said one or more refrigeration machines 214, 216, and, at the same time, the heat released from the refrigerant can be made use of elsewhere in the refrigeration technique system, for instance in heating a building.

**[0017]** Figure 3 shows something more of the building engineering system. In an embodiment according to Figure 3, the heat exchanger 202 transfers heat along the accumulation pipe system 308 to heat storage 302, which may indirectly serve as said other destination 204 mentioned in connection with Figure 2. As mentioned earlier, the refrigerant in the accumulation pipe system 308 may be, for instance, water or the like. Beside one or more refrigeration machines 214, 216 in the refrigeration equipment 212, there may be an additional heat exchanger part 300 which is connected in parallel with the evaporator part 208 and the expansion valve part 206 in the pipe system 108. There is the same pressure difference over the parts connected in parallel, and the flow of refrigerant is distributed to different parts. The additional heat exchanger part 300 is also connected to a heat transfer pipe system 450 in cascade with the supercooler part 200 and at least one other part 204 of the building engineering system, which is in Figure 3 represented by a source 304 but which may, in a general case, equally well be another part. In cascade connection, the same flow of heat carrier is directed through all parts, and the pressure difference over each part is smaller than the total pressure difference over the cascaded parts. The additional heat exchanger part 300, which may be the other destination 204 mentioned in connection with Figure 2, may operate like the heat exchanger 202. The additional heat exchanger part 300 may comprise an expansion valve 320 in the same way as the refrigeration equipment 212. Then, the evaporated refrigerant receives heat from the heat carrier of the pipe system 108.

**[0018]** The additional heat exchanger part 300 may receive heat from the supercooler part 200, from a heat carrier flowing along a heat transfer pipe system 306, and transfer at least part of the received heat to the pipe system 108 between the evaporator part 208 and the heat exchanger 202, from which the heat may be further transferred to the heat exchanger 202 by the refrigerant. The additional heat exchanger part 300 may also receive heat from a predetermined heat source 304 along the heat transfer pipe system 306 and transfer the received heat to the pipe system 108 between the evaporator part 208 and the heat exchanger 202, from which the heat is further transferred to the heat exchanger 202 by the refrigerant. From the heat exchanger 202, the heat may be transferred onwards by the heat carrier along the accumulation pipe system 308 to the heat storage 302. The heat storage 302 may be for example a boiler, which may be thermally insulated to restrict escaping of heat and which may have a predetermined volume. Heat accumulated in the heat storage 302 may be used in buildings, for instance for heating and domestic hot water. Heating of the building 10 may, in turn, be implemented for example as floor heating, radiator heating, and/or heating of air in ventilation. The predetermined heat source 304 may be, for example, a ground circuit in the ground but it is not restricted to that.

**[0019]** The more heating capacity is supplied by the heat storage 302 to heat the building 10, the more heat can be transferred from the supercooler part 200 to the pipe system 108 by the additional heat exchanger part 300. Also, the more heating capacity is supplied by the heat storage 302 to heat the building 10, the more heat can be transferred from the predetermined heat source 304 to the pipe system 108 by the additional heat exchanger part 300. In other words, when consumed, heat of the heat storage 302 is supplemented by heat received by the heat exchanger part 300 to the extent that is necessary. This may take place in accordance with a desired continuous function.

**[0020]** In discontinuous action, the additional heat exchanger part 300 may be connected to transfer heat from the predetermined heat source 304 to the pipe system 108 if the heating capacity supplied from the heat storage 302 to heat the building is greater than what was predetermined. Then, the heating capacity to be transferred may remain constant or increase if the consumption of heat in the building 10 increases. Otherwise, the additional heat exchanger part 300 may omit transfer of heat from the predetermined heat source 304 and/or supercooler part 200 to the pipe system 108.

**[0021]** Let us now examine a slightly larger building engineering system shown in Figure 4 and comprising, in addition to what was shown in the preceding figures, an air conditioner 400. The air conditioner 400 may comprise one or more outdoor air intake valves 420, one or more outdoor air feed openings 424, an intake channel 428 between the intake valve 420 and the feed opening 424, one or more indoor air bleeder valves 422, one or more indoor air intake openings 426 and a bleeder channel 430 between the indoor air intake opening 426 and the bleeder valve 422. Further, the air conditioner 400 may comprise an intermediate valve 432 between the intake channel 428 and the bleeder channel 430. Desired part of the indoor air flowing in the bleeder channel 430 and to be removed may be circulated by the intermediate valve 432 back to the intake channel 428, from which said part returns to the inside of the building 10. The proportion of the air taken from the outside to the circulated indoor air in the feed opening 424 may be, for instance, 50%. Thus, half of the incoming air may be new air taken from the outside, the other half being air returning directly from the inside back to the inside.

**[0022]** The heat storage 302 may be in connection to the air conditioner 400, and heat of the heat storage 302 may, if required, be transferred to the air conditioner 400 for instance to heat the building 10 or to keep it warm. In general, the building 10 must be heated on cold days, which usually occur during cold seasons. In Finland, heating is often required not only in winter but also in spring and autumn. Further, warm water with a temperature of about 30 °C, for example, may be supplied from the heat storage 302 to floor heating 494 or entrance space machines 496. The efficiency of the floor heating can be controlled by means of a valve 498.

**[0023]** The heat transfer pipe systems 220 and 306 in Figure 3 may be connected to each other to form a pipe system 450, as has been done in Figure 4. In Figure 4, the heat source 304 is a ground circuit 470. The heat carrier in the heat transfer pipe system 450 is the same as the heat carrier in the heat transfer pipe system 220. Thus, in the present solution, refrigerant in the pipe system 108 and a first and a second heat carrier in the pipe systems 308 and 450 can be used for heat transfer.

**[0024]** The building engineering system may comprise a heater 402 for heating the air to be taken into the building, and the supercooler part 200 may transfer heat from the refrigerant of the pipe system 108 to the heater 402 of the building along with a third heat carrier flowing in the heat transfer pipe system 450. The heater 402, which may serve as the other destination 204 mentioned in the context of Figure 2, may be positioned in the air conditioner 400. In the heater 402, the latent heat in the heat carrier may be transferred into the air to be supplied into the inside of the building 10 in the channel 428 after the indoor air and outdoor air have been mixed. The heat may be transferred into the air from the heat carrier by conduction through the pipe system 450 and/or by radiation from the heated pipe system 450.

**[0025]** The heat received by the supercooler part 200 may be transferred to the heater 402 as follows, for example. The heat carrier arriving from the ground circuit 470 may be at a temperature of about +5 °C, and it may be pumped by a pump 452 to a valve 454, which mixes heat carrier returning from the heater 402 and having a temperature of, for example, +20 °C and heat carrier arriving from the ground circuit 470 with each other. The pump 452 may thus operate at partial power, which may be, for example, 50% of the total power. The mixing proportion may be for instance about 40% of warm heat carrier and for instance about 60% of cold heat carrier having arrived from the ground circuit, which results in heat carrier with a temperature of about 12 °C. The mixing proportion may be changed in such a way that the temperature of the heat carrier going to the supercooler 200 remains constant. The mixing proportion may be changed in such a way, for example, that the temperature of the mixed heat carrier is measured by a temperature sensor 456, and when the temperature falls, the amount of cold heat carrier from the ground circuit 470 is decreased in the mixture by means of the valve. Alternatively or in addition, the valve 454 may be opened more to increase the heat carrier arriving from the heater 402 in the mixture. The heat carrier thus formed is fed to the supercooler 200. The ground circuit 470 may the other destination 204.

**[0026]** In a general case, there may be more than one supercooler 200. In the example of Figure 4, there are two 480, 482 supercoolers 200. In the supercooler 200, the temperature of the heat carrier rises by, for example, +25 °C when the refrigerant flowing in the pipe system 108 has transferred heat into it.

**[0027]** Before the supercooler 200, the temperature of the refrigerant in the pipe system 108 may be about +30 °C or slightly less. After the supercooler 200, the temperature of the refrigerant may be, for example, about +14 °C. Refrigerant may be further cooled before the expansion valve part 206 in a heat exchange part 490, which transfers heat from the refrigerant going to the expansion valve part 206 to the refrigerant in a part 492 of the pipe system 108 between the evaporator part 208 and the condenser part 202.

**[0028]** In an embodiment, the building engineering system comprises a controller 404 which may comprise a processor 406, memory 408 and a suitable computer program. The operation of the controller 404 may be based on a sequence of program commands of the computer program controlling the operation, stored in the memory 408. The sequence of control commands of the controller 404 may control the supercooler part 200 and/or the heat transfer operation of the additional heat exchanger part 300.

**[0029]** The controller 404 may control the heat exchanger part 202 to regulate heat transfer off the refrigeration equipment 212 to the heat storage 302, from which heat is transferrable to the air conditioner 400. For example, a valve 466 may guide the refrigerant partly or completely past an exchange part 468 of the heat exchanger 202.

**[0030]** A first part 480 of the supercooler 200 may transfer heat to the heat carrier by liquefying the refrigerant, and a second part 482 may cool refrigerant by transferring heat from it into the heat carrier.

**[0031]** The controller 404 may control the supercooler part 200 to regulate heat transfer from the refrigerant in the pipe system 108 to at least one other destination 204 in the building engineering system.

**[0032]** After the supercooler 200, the heated heat carrier may be pumped by means of a pump 458 through a valve 460 to the heater 402, from which it returns in return circulation through a valve 462 to the valve 454. From the valve 454, the heat carrier proceeds to the circuit part in the ground circuit 470. In Figure 4, the heat carrier proceeds from the valve 454 to the additional heat exchanger part 300, but in the case of Figure 4, the additional heat exchanger part 300 is not in operation or its operation is at its minimum. The additional heat exchanger 300 may transfer heat to the refrigerant circulating in the pipe system 108 but this is described in more detail in the context of Figure 5A, for example. In the presented solution, the heat transfer pipe system 450 is connected between the supercooler part 200 and the additional heat exchanger part 300, and the heat carrier flows first from the supercooler part 200 to the heat exchanger part 300, which is a part of the building engineering system and which may transfer received heat further to a desired location.

**[0033]** In an embodiment, the supercooler part 200 may transfer heat from the refrigerant to the heater 402 of the building by means of the circulation described above if the set value of the indoor air temperature of the building is higher than that of the outdoor air temperature. This operation is feasible if the required heating capacity for the indoor air is lower than the heating capacity of the supercooler part 200. Otherwise, the supercooler part 200 may transfer heat from the refrigerant to the heat storage 302 via the heat exchanger 202. The heater 402 in the air conditioning may be used when the outdoor temperature is, for instance, in the range of about -10 °C to +15 °C.

**[0034]** The controller 404 may control the compressor part 210, for example, to control the circulation of the carbon dioxide serving as the refrigerant through the pipe system 108 in the evaporator part 208, the expansion valve part 206 and the condenser part 104 of the refrigeration equipment 212. In this way, heat transfer to the heat storage 302 may be increased or decreased. The quicker the circulation of the refrigerant, the more heat can be transferred off the refrigerant. At the same time, also the supercooler part 200 can transfer more heat into the heat carrier circulating in the pipe system 450.

**[0035]** The controller 404 may control for instance the amount of flow of the heat carrier flowing through the supercooler part 200 per time unit. In the same way, the controller 404 may control for instance the amount of flow of the heat carrier and/or the refrigerant flowing through the additional heat exchanger part 300 per time unit. The amount of flow may be given as volume or mass, whereby the unit of the time-unit-specific amount of flow is $m^3/s$ or kg/s. Instead of or in addition to using the controller 404, controlling may also be carried out manually. The controller 404 may control the pumps 452, 458 and valves 454, 460, 462, which adjust the amounts of flow. The valves 454, 460 and 462 may be perceived as belonging to the supercooler part 200 because they affect the heat transfer capacity of the supercooler part 200 and the destination to which heat received from the pipe system 108 by the supercooler part 200 is transferred.

**[0036]** The controller 404 may also receive the temperature of the outdoor air by means of a sensor 412, which may be positioned for instance at the outdoor air intake of the air conditioner 400 or in connection with it. If the set value of the indoor temperature in a building is +19 °C and the outdoor temperature is +5 °C, air to be taken into the inside of the building may be heated by a heater 402. From a temperature sensor 410 possibly inside the building 10, in turn, data can be received on the indoor temperature of the building 10.

**[0037]** The controller 404 may also receive data from a temperature sensor 414 and/or valve 444 on the temperature and amount of flow of the water exiting the heat storage 302. In this way, the controller 404 can determine the amount of heat exiting the heat storage 302, i.e. the consumption of heat in the building. This consumption may be completely or partly replaced by heat supplied from the heater 402 into the building 10. Since the volume of the heat storage 302 is known, also the amount of heat stored in the heat storage 302 is known by means of the temperature, the volume and the specific heat capacity of the heat carrier.

**[0038]** Figure 5 shows a case where the heating capacity generated by the refrigeration equipment 212 is not sufficient to heat the building 10. Then, the additional heat exchanger part 300, whose power can be selected as desired but which can produce a thermal power of 20 kW, for example, is switched on or it is used to increase heat received from the heat carrier flowing in the heat transfer pipe system 450. Simultaneously, the valve 460 is closed so as to prevent the access of heat carrier to the heater 402. The valve 462 is used to prevent return circulation from the heater 402. Further, the valve 462 allows heat carrier to proceed from the supercooler part 200 to the additional heat exchanger part 300 in the heat transfer pipe system 450 without circulation with the heater 402. Since the additional heat exchanger part 300, which may serve as the other destination 204 mentioned in the context of Figure 2, is thus in operation, the power of the pump 452 can be raised to the maximum, i.e. to 100%, to efficiently transfer additional heat. The operation of the valves 460, 462 and possibly also that of the pump 452 can be changed if temperature $T_2$ of the heat carrier measured by a temperature sensor 510 is higher than temperature $T_3$ of the heat carrier returning from the heater 402 and measured by the temperature sensor 412. The controller 404 may receive the signals of the temperature sensors 410, 510 and control the operation of both the valves 460, 462 and the pump 452 on the basis of the data contained by the signals.

**[0039]** When the direct supply of heat from the supercooler 200 to the heater 402 has thus been interrupted, heating of the building 10 can be attended to by supplying heat from the heat storage 302 to the heater 402 along a heat transfer pipe system 512. Thus, a valve 514, which is closed in the case of Figure 4, is opened, and the heat carrier which is to be transferred in the heat transfer pipe system 512 and which may have a temperature of +35 °C, for example, can flow to a heat exchanger 516 of the ventilation. The heat exchanger 516 transfers heat into a small pipe system 518 positioned in connection with the heater 402 and closed by the valves 460, 462, in which pipe system the heat carrier is circulated by a pump 520. In the pipe system 518, the temperature of the heat carrier fed to the heater 402 may, due to heat transfer, rise to about +30 °C, for example. After the heater 402, when heat transfer has taken place, the temperature of the heat carrier may be, for example, +21 °C.

**[0040]** In this example, the temperature of the heat carrier arriving in the supercooler part 200 may be the one at which the heat carrier arrives from the ground circuit 470 or another source 304. The temperature of the heat carrier arriving from the ground circuit 470 may be, for example, +5 °C. After the supercooler part 200, the temperature of the heat carrier may be, for example, +10 °C. The valve 454 may mix heat carrier heated in the supercooler part 200 and heat carrier arriving directly from the ground circuit 470 or the like with each other, whereby the temperature of the mixture becomes for instance +7 °C. This mixture is then supplied to the additional heat exchanger part 300, where the heat carrier emits heat into the refrigerant circulating in the pipe system 108. The heat carrier is returned to a circuit in the ground circuit 470 or the like for instance at a temperature of +3 °C.

**[0041]** If the heat received by the additional heat exchanger part 300 from the ground circuit 470, which may also be the other destination 204 mentioned in the context of Figure 2, does not suffice, an embodiment shown in Figure 6A can be additionally used. The solution of Figure 6A may also be used if no heat can be taken from the ground circuit 470 or there is no ground circuit at all in the building engineering solution. In this embodiment, the building engineering system comprises an evaporator 600 for receiving heat from the air moving in the air conditioner 400. The evaporator 600 may be connected to the pipe system 108 in such a way that the refrigerant in the pipe system 108 can flow as far as to the evaporator 600. The evaporator 600, which may be positioned in the bleeder channel 430 of the air conditioner 400, may transfer the heat it has received from the air to be removed from the building to the heat storage 302 via the heat exchanger 202. The power of the evaporator 600 can be rated as desired. The power of the evaporator 600 may be, for instance, 20 kW.

**[0042]** The more heating capacity is supplied by the heat storage 302 to heat the building 10, the more heat received from the air to be removed from the building and/or from the outdoor air can be transferred to the heat storage 302 by the evaporator 600. This may take place in accordance with a desired continuous function.

**[0043]** In discontinuous action, the evaporator 600 can transfer heat received from the air to be removed from the building to the heat storage 302 if the heating capacity supplied from the heat storage 302 to heat the building is greater than what was predetermined. Otherwise, the evaporator 600 may be kept out of operation and the circulation of the refrigerant to the evaporator 600 prevented. The circulation of the refrigerant to the evaporator 600 may be controlled by means of an expansion valve 503, which can control the amount of flow of the refrigerant circulation. The expansion valve 503 may also serve as a switch which is either on or off. The valve 503 may, in turn, be controlled by the controller 404. Thus, the controller 404 may receive data from the temperature sensor 414 and/or flow sensor 444 on the temperature and amount of flow of the water exiting the heat storage 302. When the amount of flow of the water exiting the heat storage 302 increases, the amount of heat received from the evaporator 600 can be increased. There may also be a limit for the operation of the evaporator 600, from which its operation is started. If the amount of flow of the water exiting from the heat storage 302 exceeds the predetermined limit, the evaporator 600 is started up either at a constant power or at an increasing heat transfer power depending on the amount of flow.

**[0044]** Figure 6B shows a case according to Figure 6A, in which the temperature of the outdoor air is -25 °C and the humidity 80%, for example, at point A. When outdoor air is mixed into air removed from the inside and having passed through a heat recovery part 602 at point B, the temperature of the mixture becomes about -22 °C and the humidity about 90%, for example, at point C. After the air has gone through the evaporator 600, its temperature is -30 °C and humidity 100% at point D. Thus, heat has been taken from the outdoor air to the inside. The incoming air, in turn, goes through the heat recovery part 602, whereby its temperature is +8 °C and humidity 6% at point E. Further, the incoming air is mixed with some of the air to be removed from the inside and having a temperature of +19 °C and humidity of 7% at point F. Thus, the temperature of the mixture is 12 °C and humidity 6% at point G. The incoming air may be further heated with a heater 402, whereby the building 10 is provided with air with a temperature of +26 °C and humidity of 4% at point H.

**[0045]** In an embodiment shown in Figure 7, the evaporator 600 can be connected in operation if the additional heat exchanger part 300 is transferring heat from the predetermined heat source 304 to the pipe system 108 and if the air conditioning of the building 10 is in indoor circulation. Indoor circulation means that no air is taken from the outside into the building 10, and no air is guided out of the building 10. This can be done for example at night or on days when there are no people in the building 10. The controller 404 may control the air conditioner of the building engineering system to operate in indoor circulation 400 by opening the intermediate valve 432 or leaving it open, by closing the valves 434, 436 or by controlling the evaporator 600 to operate. The valve 434 closes the bleeder channel, and the valve 436 closes the intake channel to allow indoor circulation. In this state, the indoor air of the building 10 is heated with the heater 402, in which heat arrives from the heat storage 302. The heat storage is provided with heat by the evaporator part 208 of the refrigeration equipment 212, the evaporator 600. In addition, heat may also be generated by a circuit in the ground circuit 470 via the additional heat exchanger part 300.

**[0046]** In an embodiment, the air conditioner 400 of the building 10 may supply air arriving in the building to cool the air arriving in the building through the evaporator 600 and to decrease the humidity in the air by condensing the humidity in the air conditioner 400. This embodiment is shown in Figure 8A. This function may be necessary on a humid and hot summer day. The evaporator 600 may, in this embodiment, comprise a water removal system 800, which transfers the condensed water off the evaporator 600 for instance to the floor drain of the building 10. In an embodiment where the refrigeration equipment 212 comprises both a refrigerator and a freezer side by side, the evaporator 600 is connected in parallel with the refrigerator, which serves as the refrigeration machine, instead of the freezer. Instead of being connected in parallel with a refrigerator, the refrigeration machine may be connected in parallel with a cooler. Instead of being connected in parallel with one refrigerator or cooler, the evaporator 600 may be connected in parallel with refrigerators, coolers or a combination of these. Connecting may be carried out by a valve 502, to which pipes 504 and 506 are connected. The pipes 504 are connected to the suction line of the freezer 208. The pipe 506 is connected to the suction line of the freezer or cooler 210. The pipe 507 is connected to a liquid line common to the freezer and the refrigerator and/or cooler. Drying of indoor air in the building 10 intensely reduces the water condensing in the refrigeration apparatuses. Thus, when the space in question is a shop, no condensed water can leak into the food products in the refrigeration apparatuses. Further, no condensed water flows along the refrigeration apparatuses on the floor, which would possibly cause slipping and decay and/or moulding of structures. In dry air, also the glass in the refrigeration apparatuses remain transparent, which makes it easy to look for products in the refrigeration apparatuses without opening the glass elements.

**[0047]** In addition, the building engineering system may comprise, outside the building, a condenser 820, to which the excess heat accumulated in the building engineering system can be transferred and from which it can be condensed to the outdoor air. With a valve 822, the refrigerant may be replaced completely or partially and guided to circulate to the condenser 820. The controller 404 may control the valve 822 on the basis of the data it has received concerning temperatures, humidity and/or flow. This state may be necessary on hot days.

**[0048]** Air can be removed out of the building 10 via a second bleeder valve 812.

**[0049]** Figure 8B shows a diagram of drying indoor air. At point A, the temperature of the outdoor air is +26 °C, for example, and the humidity 55%, for example. At point B/C, the air has proceeded to the heat recovery part 602 of the air conditioner 400, where the air temperature falls to +18 °C but the humidity rises to 100%. At point D, the air has gone through the evaporator 600, whereby its temperature is +8 °C and the humidity 100%. Then, the water in the air condenses in the evaporator 600, from which it exits. At point E, the air has proceeded again through the heat recovery part 602, whereby the heat removed in the heat recovery part 602 has been returned to it. Then, the air temperature is +18 °C and the humidity 50%. This air can be supplied into the building 10 or it may also be heated to some extent by heat that has been transferred from the evaporator 600 to the heat storage 302 and is transferrable for instance according to Figure 5 to the heater 402, which heats the incoming air.

**[0050]** Air inside the building 10 can be dried when the outdoor air is humid and warmer than the indoor air in the building. Then, a humidity sensor 814 inside the building 10 may send data to the controller 404, which sets the building engineering system to decrease the humidity of indoor air in the manner shown by Figures 8A and 8B. Further, the controller 404 may obtain data from the indoor temperature sensor 410 and/or outdoor temperature sensor 412. If the humidity inside the building is greater than a predetermined threshold value, dehumidification can be started. The threshold value may be a value between 40% and 100%, for example. Furthermore, if the outdoor temperature is higher or the absolute value of the difference between the outdoor temperature and the indoor temperature is lower than a predetermined threshold value, dehumidification can be started. The set value and the measured value of the indoor air may here be regarded as the indoor temperature. The threshold value of the absolute value of the difference between the temperatures may be 5 °C, for example. The threshold value may also be 2 °C. Thus, if the indoor temperature is +20 °C and the temperature outside is +18 °C, dehumidification can be performed.

**[0051]** In an embodiment shown by Figure 9, in order to defrost the ice formed in the evaporator 600, the air conditioner 400 may be set to circulate the indoor air of the building through the evaporator 600. The air conditioner 400 may circulate the indoor air of the building through the evaporator 600 for a predetermined time. This may be implemented in such a way that the air conditioner 400 may comprise a pressure sensor 900. The air conditioner 400 can circulate the indoor air of the building through the evaporator 600 if the pressure measured by the pressure sensor 900 exceeds a predetermined threshold value. In an embodiment, the pressure sensor 900 may supply the pressure information to the controller 404, and the controller 404 may set the air conditioner 400 to circulate the indoor air through the evaporator 600. Then, the controller 404 may close the bleeder valve 422 of the air conditioner 400, which lets out indoor air, and open an intermediate valve 902, from which the air inside the air conditioner 400 is supplied to the intake channel 428 supplying air to the inside of the building 10.

**[0052]** Figure 10 shows the requirement for heating and cooling energy in different seasons in a Finnish grocery shop. It can be observed that the refrigeration equipment can attend to the heat demand of the property during the coldest time when the requirement for refrigeration capacity is lower and compressor capacity is released for taking care of the heating demand. On the basis of this information, the refrigeration system, heating system and air conditioning system are integrated to form one energy centre in the shop, which centre can be controlled by a common automatic system. The energy centre attends to all the heating and cooling demand of the property.

**[0053]** The heat generated by the compressor part 210 of the refrigeration equipment 212 is, for most of the time during a year, sufficient for heating the building 10 and cooling the refrigeration apparatuses. The horizontal lines shows an area 1000, which means that in addition to cooling energy, also heat is taken from the compressor part 210 during the cold season to heat the building 10. In this way, the load of the compressor part 210 can be kept even throughout the year. More heat energy 1002 for heating the building 10 is obtained from, for example, the ground heat 470 and the evaporator 600, which receives heat from air moving in the air conditioner 400.

**[0054]** Figure 11 is a flow chart of a method. In step 1100, the compressor part 210 is used to circulate carbon dioxide serving as the refrigerant through the pipe system 108 in the supercooler part 200 and in the expansion valve part 20, the evaporator part 208 and the condenser part 104 of the refrigeration equipment 212. In step 1102, the heat exchanger part 202, which is in connection with the condenser part 104, is used to transfer heat off the refrigeration equipment 212 to the heat storage 302, from which heat is transferrable to the air conditioner 400. In step 1104, the supercooler part 200, which is connected to the pipe system 108 between the condenser part 104 and the expansion valve part 206, is used to transfer heat from the refrigerant of the pipe system 108 with the heat carrier of the heat transfer pipe system 450 to at least one other part 204 of the building engineering system and/or to the additional heat exchanger part 300, which is connected to the pipe system 108 in parallel with said evaporator part 208 and expansion valve part 206 and to the heat transfer pipe system 450 in cascade with the supercooler part 200 and at least one other part 204 of the building engineering system.

**[0055]** Instead of or in addition to using a processor and memory, controlling may be implemented as one or more integrated circuits, such as an application-specific integrated circuit ASIC. Other equipment embodiments are also feasible, such as a circuit constructed of separate logic devices. A hybrid of these different implementations is also possible.

**[0056]** Even though the invention has been described above with reference to the examples according to the attached drawings, it is clear that the invention is not restricted thereto but may be modified in many ways within the scope of the accompanying claims.

## Claims

1. A building engineering system, characterized in that the building engineering system comprises

heat storage (302);

refrigeration equipment (212) having carbon dioxide as refrigerant and comprising an evaporator part (208), expansion valve part (206), compressor part (210) and condenser part (104);

a pipe system (108) for circulating the refrigerant in said refrigeration equipment (212);

a heat exchanger (202) connected to the pipe system (108) before the condenser part (104) to transfer heat off the refrigeration equipment (212) to the heat storage (302);

a supercooler part (200) connected to the pipe system (108) between the condenser part (104) and the expansion valve part (206);

an additional heat exchanger part (300) connected to the pipe system (108) in parallel with said evaporator part (208) and expansion valve part (206) to allow heat to be transferred from the additional heat exchanger part (300) to the refrigerant of the pipe system (108) and further to the heat exchanger (202); and

a heat transfer pipe system (450) arranged to connect the supercooler part (200) and at least one of the following: the additional heat exchanger part (300), at least one other part (204) of the building engineering system to allow heat to be transferred from the supercooler part (200) to the additional heat exchanger part (300) and/or the at least one other part (204) of the building engineering system by means of heat carrier in the heat transfer pipe system (450).

2. A building engineering system according to claim 1, characterized in that the building engineering system comprises a heater (402) for heating the air supplied to the inside of a building, and the supercooler part (200) is arranged to transfer heat to the heater (402) of the building.

3. A building engineering system according to claim 2, characterized in that the supercooler part (200) is arranged to transfer heat to the heater (402) of the building when the set value for the indoor air temperature of the building is higher than that of the outdoor air temperature and when the

heating capacity requirement for the indoor air is lower than the heating capacity of the supercooler part (200).

4. A building engineering system according to claim 1, characterized in that the additional heat exchanger part (300) is connected by the heat transfer pipe system (450) to a predetermined heat source (304), and the additional heat exchanger part (300) is arranged to transfer heat from a predetermined heat source (304) to the pipe system (108) between the evaporator part (208) and the heat exchanger (202) to be further transferred via the heat exchanger (208) to the heat storage (302) of the building (10).

5. A building engineering system according to claim 1, characterized in that the more heating capacity the heat storage (302) is arranged to supply to heat the building, the more heat the heat exchanger part (300) is arranged to transfer to the pipe system (108), from which the heat exchanger part (202) is arranged to transfer heat to the heat storage (302).

6. A building engineering system according to claim 1, characterized in that the building engineering system comprises an air conditioner (400) and an evaporator (600) for receiving heat from air moving in the air conditioner (400), the evaporator (600) is connected to the pipe system (108), and the evaporator (600) is arranged to transfer the received heat to the heat storage (302) via the heat exchanger (202).

7. A building engineering system according to claim 6, characterized in that the more heating capacity the heat storage (302) is arranged to supply to heat the building, the more heat received from air removed out of the building the evaporator (600) is arranged to transfer to the heat storage (302) of the building (10) via the heat exchanger (202).

8. A building engineering system according to claim 6 or 7, characterized in that the evaporator (600) is connectable in operation if the additional heat exchanger part (300) is transferring heat from the predetermined heat source (304) to the pipe system (108) and if the air conditioning of the building (10) is in indoor circulation.

9. A building engineering system according to claim 6, characterized in that the evaporator (600) is arranged to transfer the air arriving in

the building (10) through itself and to cool it to decrease humidity in the air by condensing the humidity in the air conditioner (400).

10. A building engineering system according to claim 9, characterized in that the evaporator (600) comprises a water removal system (800) to transfer the condensed water off the air conditioner (400).

11. A building engineering system according to claim 6, characterized in that, in order to defrost the ice formed in the heat pump (600), the evaporator (600) is arranged to circulate indoor air of the building (10) through itself.

12. A building engineering system according to claim 11, characterized in that the building engineering system comprises a pressure sensor (900) inside the air conditioner (400), the evaporator (600) is arranged to circulate indoor air of the building (10) through itself if the pressure measured by the pressure sensor (900) exceeds a predetermined threshold value.

13. A building engineering system according to claim 12, characterized in that the the evaporator (600) is arranged to circulate indoor air of the building (10) through itself for a predetermined time.

14. A method for transferring heat in a building, characterized by

circulating (1100) carbon dioxide serving as the refrigerant by a compressor (210) through a pipe system (108) in a supercooler part (200), and in an expansion valve part (206), evaporator part (208) and condenser part (104) of the refrigeration equipment (212);

transferring (1102) by a heat exchanger (202), which is connected to the pipe system (108) before the condenser part (104), heat off the refrigeration equipment (212) to heat storage (302), from which heat is transferrable to an air conditioner (400);

transferring (1104) by a supercooler part (200), which is connected to the pipe system (108) between the condenser part (104) and the expansion valve part (206), heat from the refrigerant of the pipe system (108) with heat carrier of a heat transfer pipe system (450) to at least one other desired part (204) of the building engineering system and/or to an additional heat exchangtor part (208) and expansion valve part (206) and to the heat transfer pipe system (450) in cascade with the supercooler part 200 and the at least one other part (204) of the building engineering system.

15. A method according to claim 14, characterized by transferring heat from the supercooler part (200) to a heater (402) of the building (10), and heating air taken into the inside of the building (10) by the heat received by the heater (402).

16. A method according to claim 15, characterized by transferring heat from the supercooler part (200) to the heater (402) of the building when the set value for the indoor air temperature of the building is higher than that of the outdoor air temperature and when the heating capacity requirement for the indoor air is lower than the heating capacity of the supercooler part (200).

17. A method according to claim 14, characterized by transferring heat by the additional heat exchanger part (300) from a predetermined heat source (304) to the pipe system (108) between the evaporator part (208) and the heat exchanger (202) to be further transferred via the heat exchanger (208) to the heat storage (302).

18. A method according to claim 14, characterized by the fact that the more heating capacity is supplied by the heat storage (302) to heat the building, the more heat is transferred by the heat exchanger part (300) to the pipe system (108), from which the heat is transferred via the heat exchanger (202) to the heat storage (302).

19. A method according to claim 14, characterized by receiving by an evaporator (600) connected to the pipe system (108) heat from air moving in the air conditioner (400), and transferring the heat received by the evaporator (600) to the heat storage (302) via the heat exchanger (202).

20. A method according to claim 19, characterized by the fact that the more heating capacity is supplied by the heat storage (302) to heat the building, the more heat received from air removed from the building is transferred to the heat storage (302) via the heat exchanger (202) by the evaporator (600).

21. A method according to claim 18 or 20, characterized by connecting the evaporator (600) in operation if the additional heat exchanger part (300) is transferring heat from a predetermined heat source (304) to the pipe system (108) and if the air conditioning of the building is in indoor circulation.

22. A method according to claim 19, characterized by supplying the air arriving in the building through the evaporator (600) to cool the air arriving in the building and to decrease humidity in the air by condensing the humidity in the air conditioner (400).

23. A method according to claim 22, characterized by transferring the condensed water by a water removal system (800) from the evaporator (600) to the floor drain of the building.

24. A method according to claim 19, characterized by, in order to defrost the ice formed in the evaporator (600), circulating indoor air of the building (10) through the evaporator (600).

25. A method according to claim 24, characterized by circulating indoor air of the building (10) through the evaporator (600) if the pressure measured by a pressure sensor (900) which measures pressure over the evaporator (600) exceeds a predetermined threshold.

26. A method according to claim 24, characterized by circulating indoor air of the building (10) through the evaporator (600) for a predetermined time.

27. A control system for a building engineering system according to claim 1, characterized in that

the control system comprises a controller (404) which is arranged to receive measurement data from the building engineering system; and

control, on the basis of the received measurement data, the transfer of heat of a supercooler part (200) to at least one other destination (204) of the building engineering system through a heat transfer pipe system (450).

28. A control system according to claim 27, characterized in

part (300) to regulate heat transfer to a pipe system (108) between an evaporator part (208) and a heat exchanger (202) and to control the heat exchanger (208) to regulate heat transfer to heat storage (302).

29. A control system according to claim 27, characterized in that the controller (404) is arranged to control the building engineering system to regulate heat transfer from the supercooler part (200) to a heater (402) of an air conditioner (400).

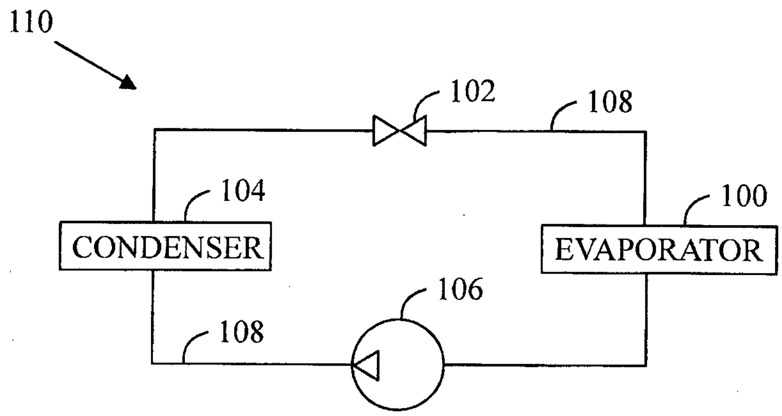
110
102
108
104
CONDENSER
100
EVAPORATOR
106
108

FIG. 1

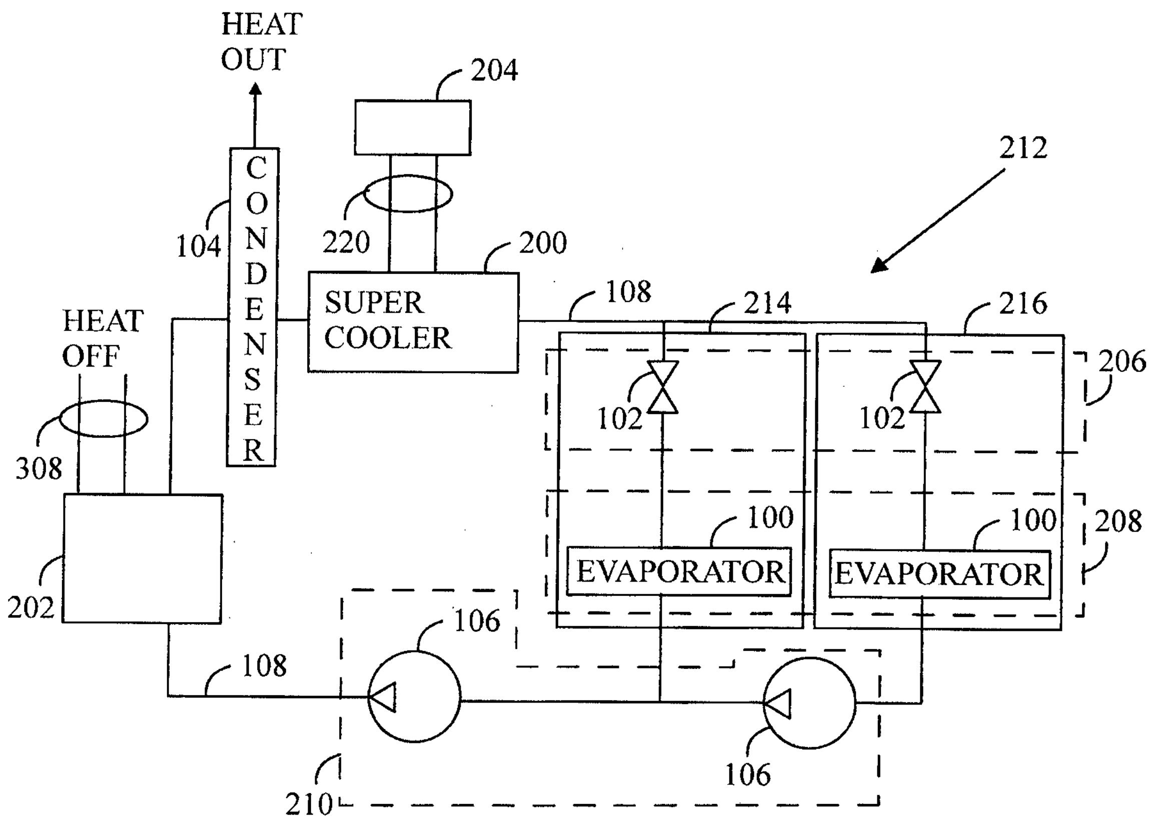
HEAT
OUT
204
212
C
O
N
D
E
N
S
E
R
104
220
200
HEAT
OFF
SUPER
COOLER
108
214
216
206
102
102
308
100
100
208
EVAPORATOR
EVAPORATOR
202
106
108
106
210

FIG. 2

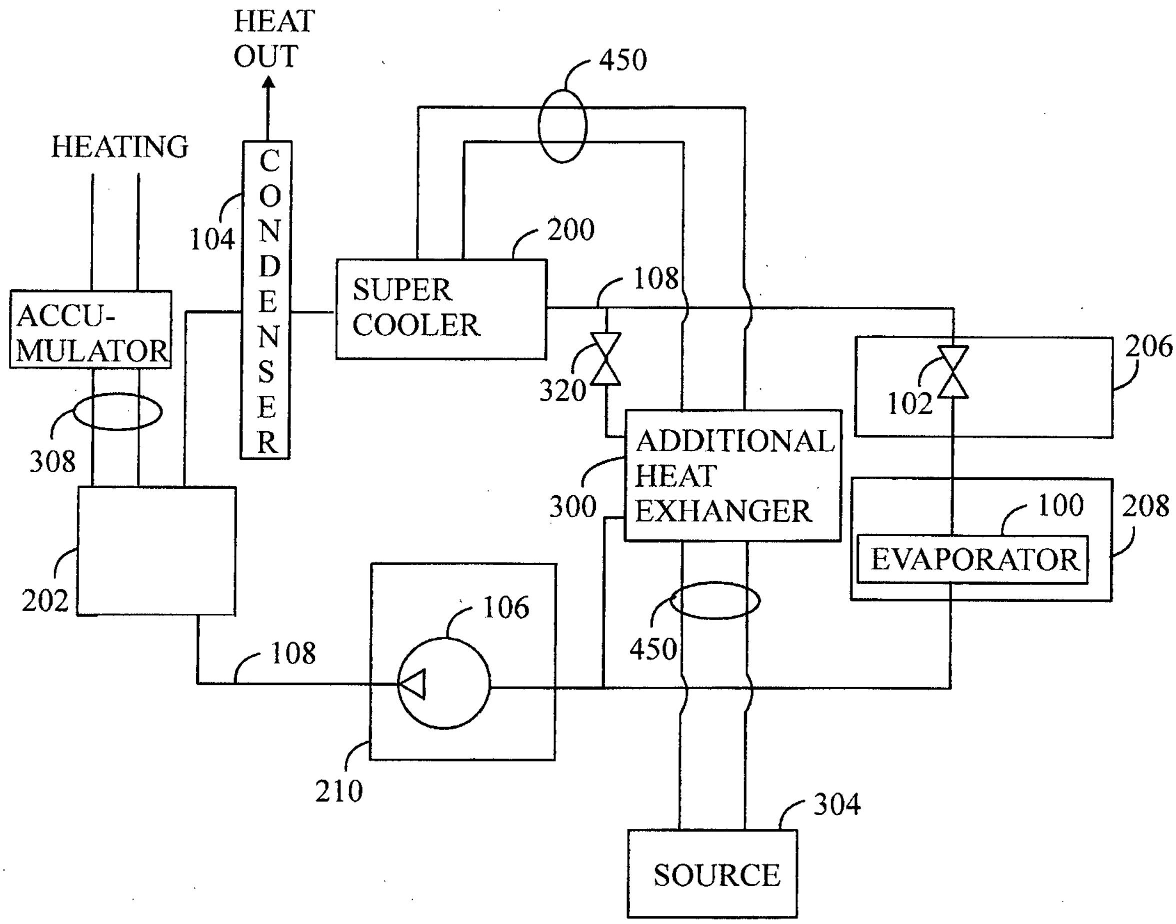
HEAT
OUT
450
HEATING
CONDENSER
104
200
SUPER
COOLER
108
ACCU-
MULATOR
206
320
102
ADDITIONAL
HEAT
EXHANGER
308
300
100
208
EVAPORATOR
202
106
450
108
210
304
SOURCE

FIG. 3

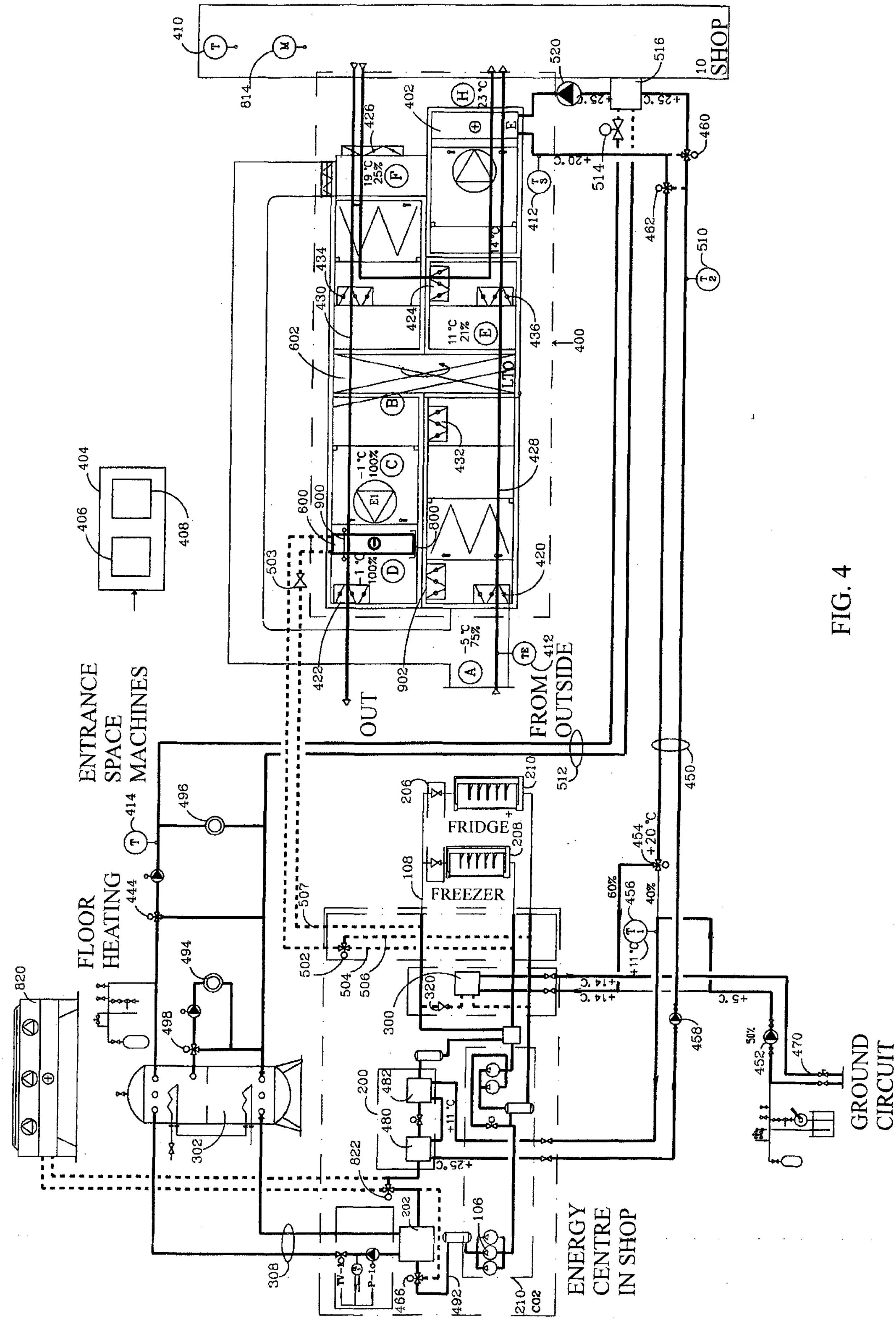
SHOP
ENTRANCE SPACE MACHINES
FLOOR HEATING
FRIDGE
FREEZER
OUT
FROM OUTSIDE
LTO
ENERGY CENTRE IN SHOP
GROUND CIRCUIT
CO2

FIG. 4

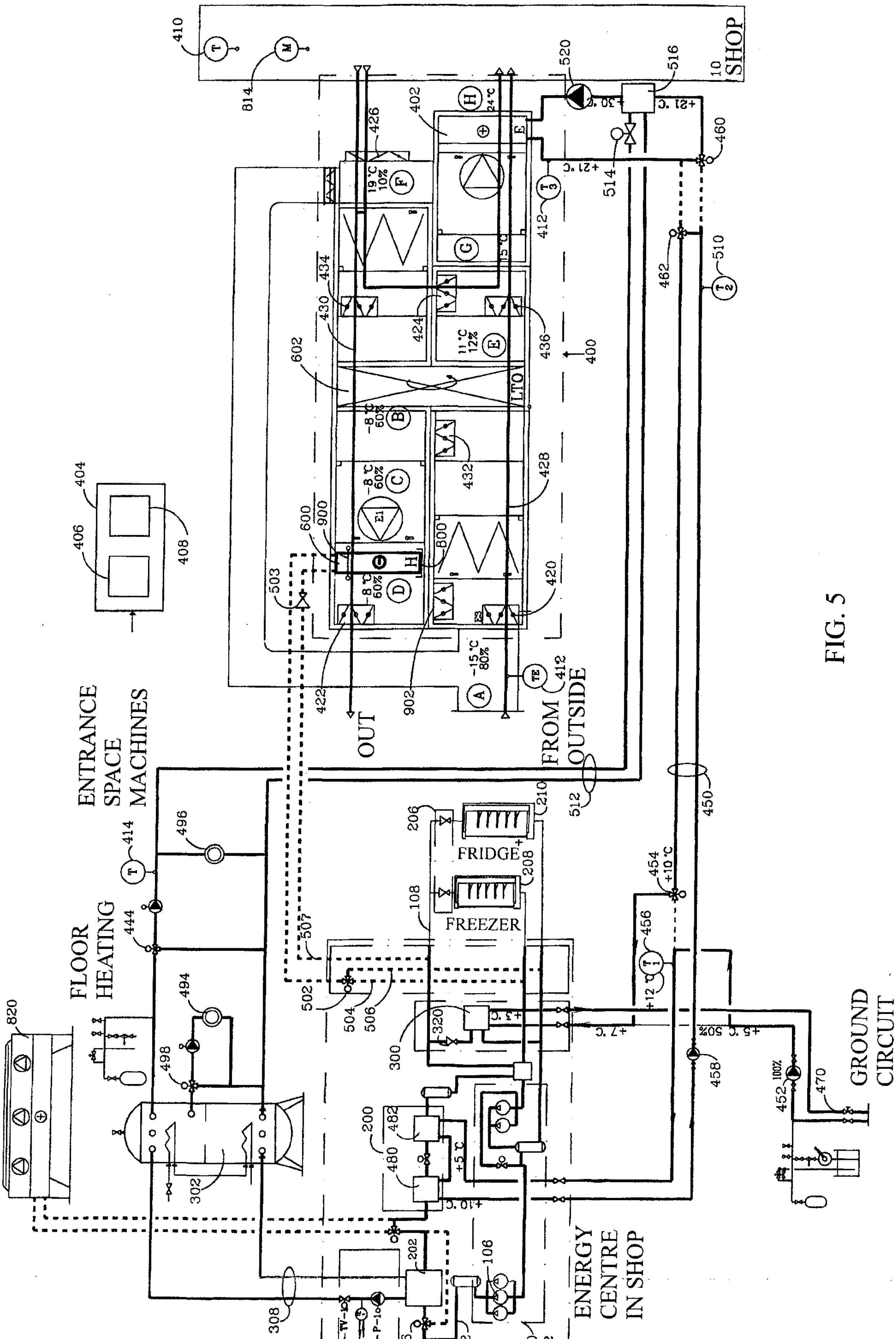
SHOP
10
410
814
520
516
402
426
ENTRANCE
SPACE
MACHINES
FLOOR
HEATING
OUT
FROM
OUTSIDE
LTO
400
602
430
434
424
436
432
428
420
422
902
600
900
800
503
404
406
408
820
414
444
496
494
498
302
308
466
492
202
106
200
480
482
300
320
502
504
506
507
FRIDGE
FREEZER
206
208
210
108
512
450
454
456
458
452
470
460
462
510
514
412
ENERGY
CENTRE
IN SHOP
GROUND
CIRCUIT
CO2

FIG. 5

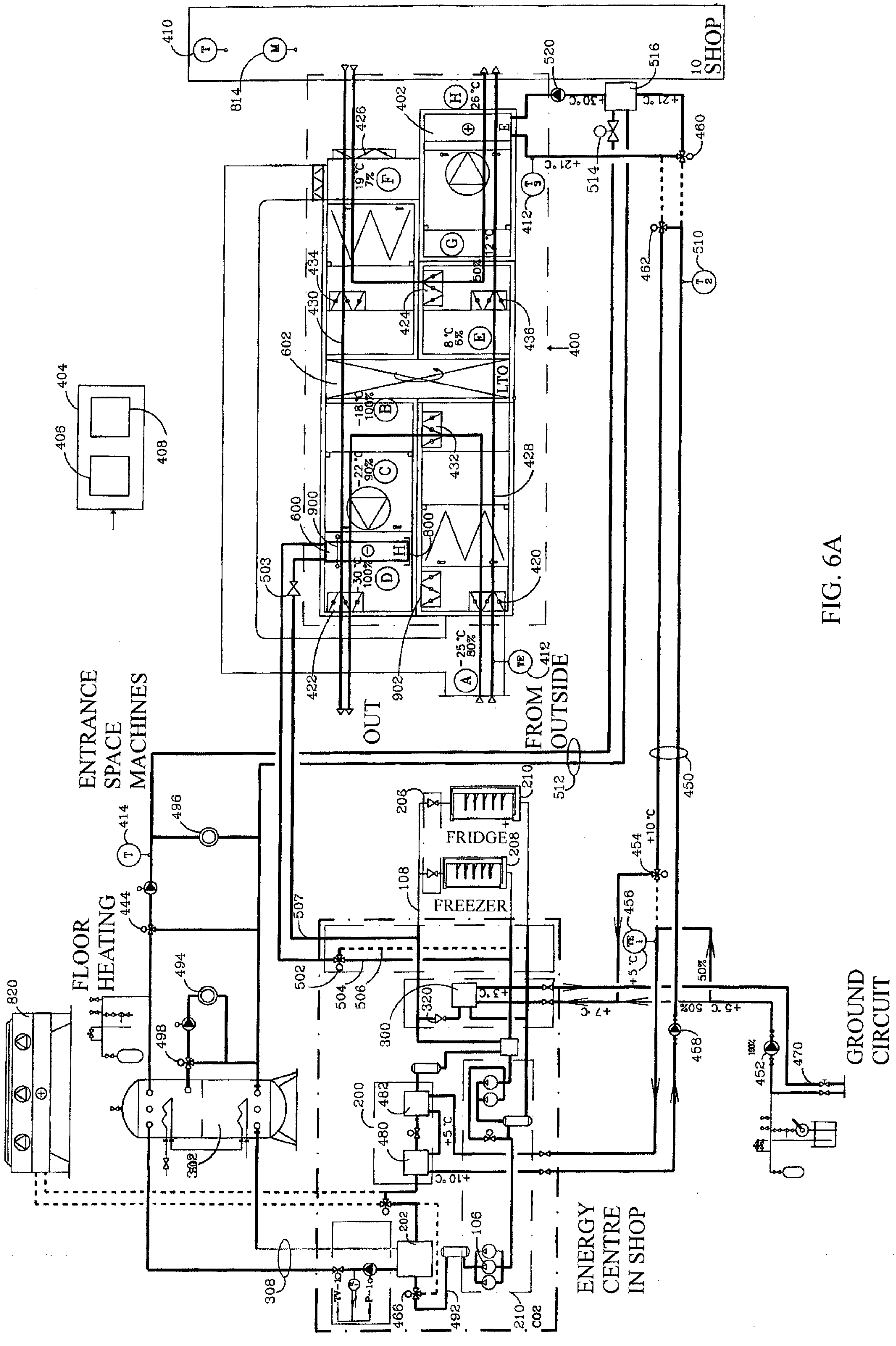
SHOP
OUT
FROM OUTSIDE
ENTRANCE SPACE MACHINES
FLOOR HEATING
FRIDGE
FREEZER
ENERGY CENTRE IN SHOP
GROUND CIRCUIT
LTO

FIG. 6A

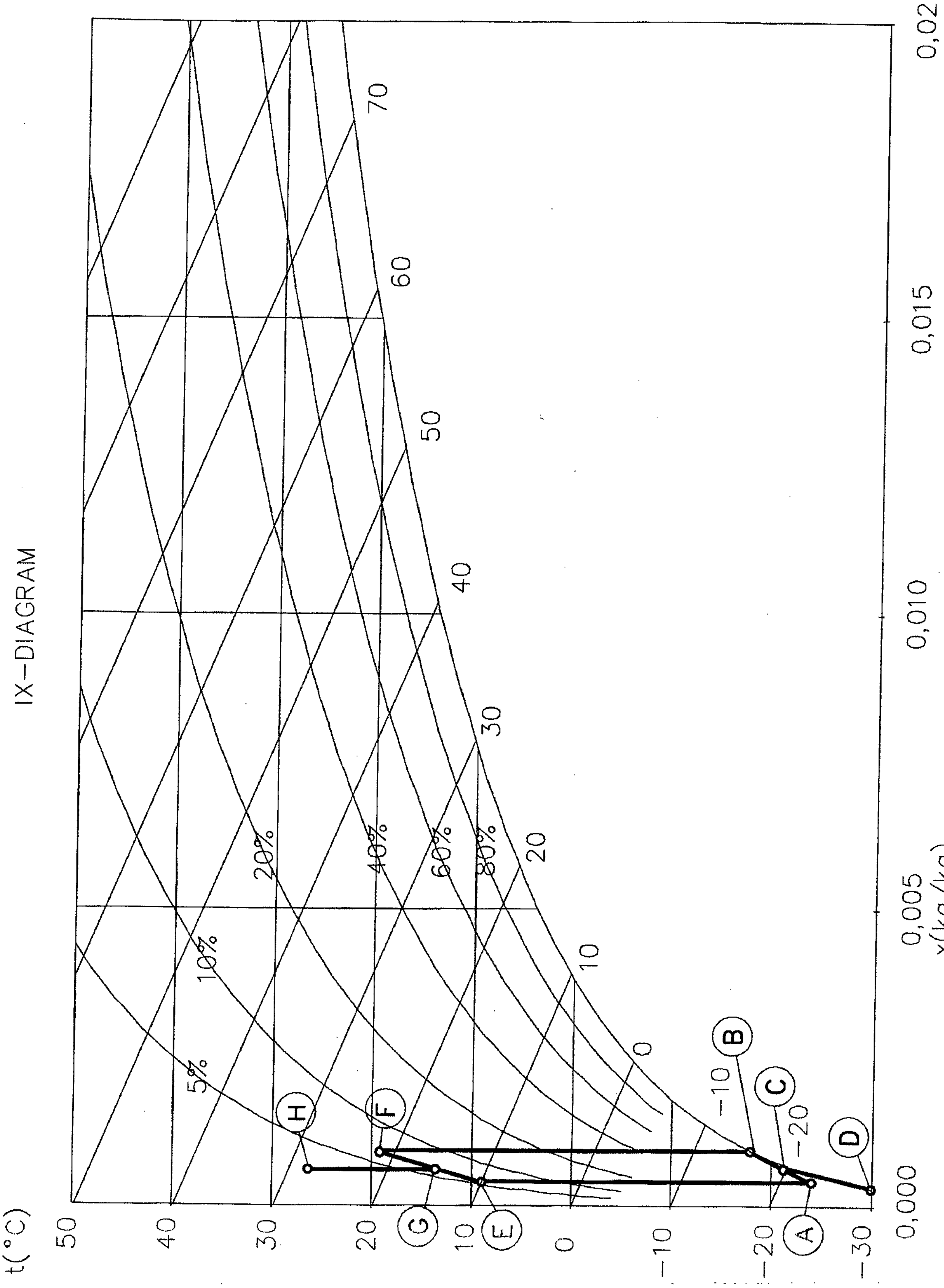
IX-DIAGRAM
t(°C)
50
40
30
20
10
0
-10
-20
-30
0,000
0,005
0,010
0,015
0,020
x(kg/kg)
5%
10%
20%
40%
60%
80%
A
B
C
D
E
F
G
H

FIG. 6B

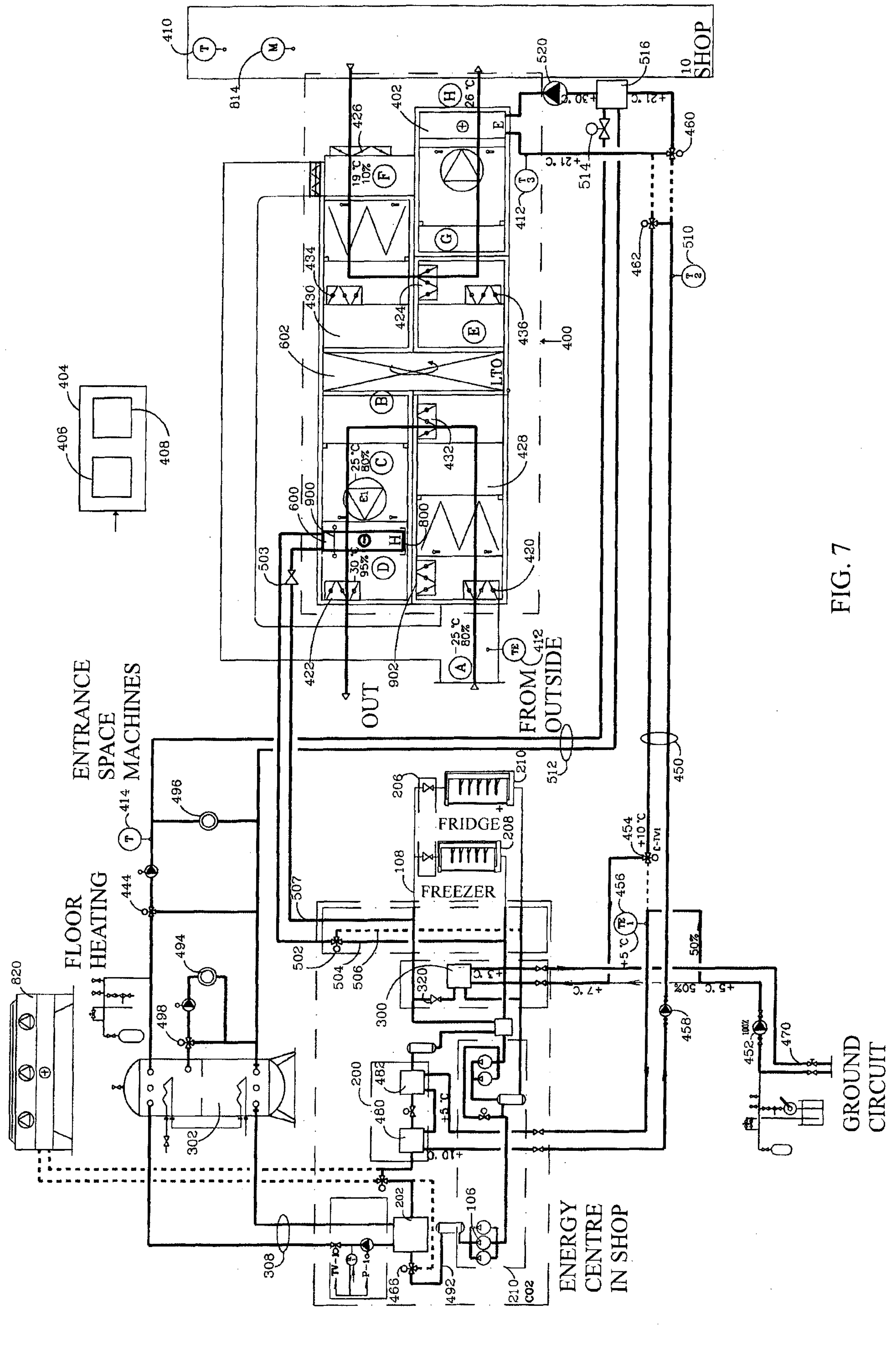
SHOP
10
OUT
FROM OUTSIDE
LTO
FRIDGE
FREEZER
ENTRANCE SPACE MACHINES
FLOOR HEATING
ENERGY CENTRE IN SHOP
GROUND CIRCUIT
CO2

FIG. 7

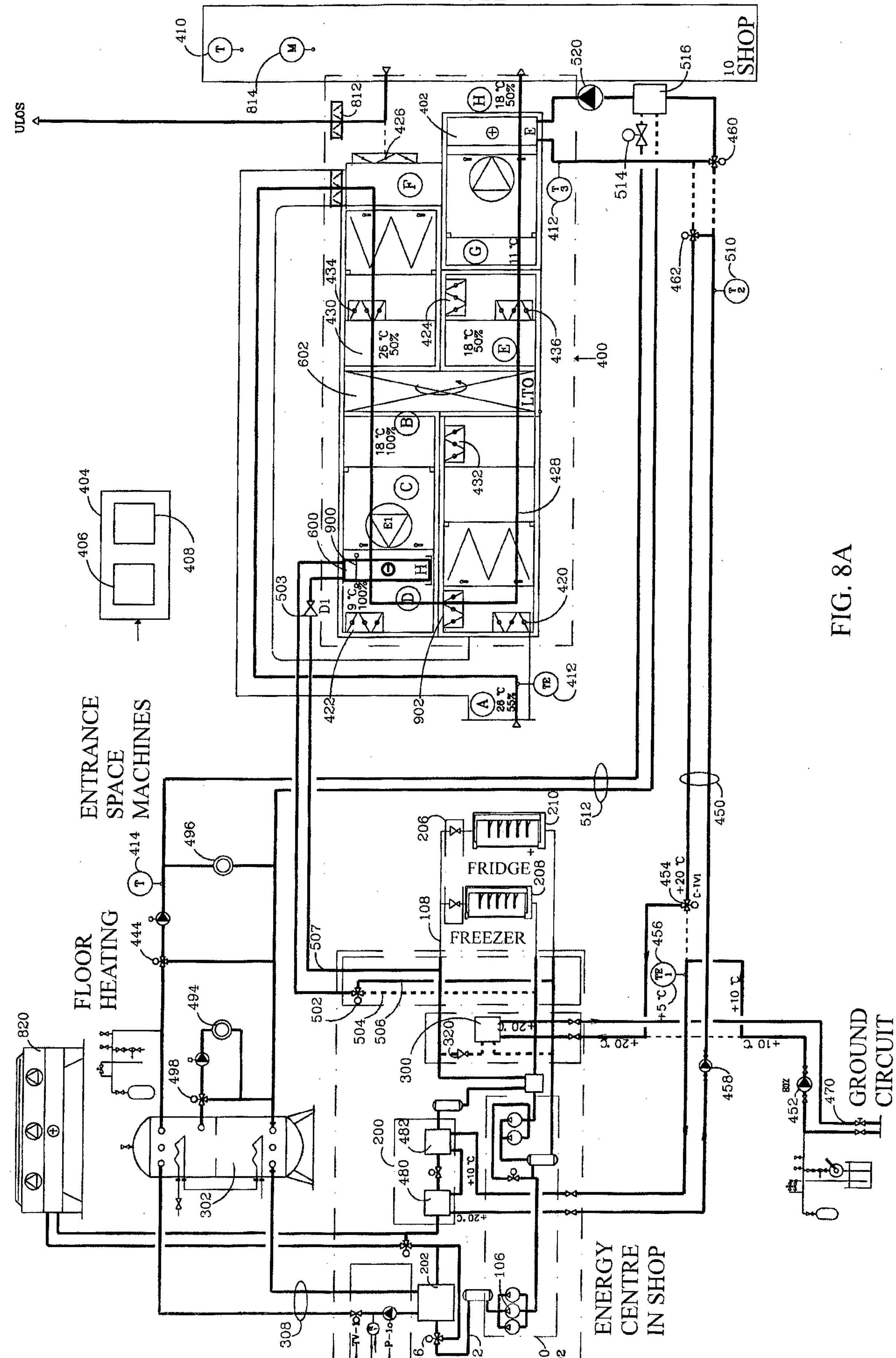
SHOP
ULOS
ENTRANCE
SPACE
MACHINES
FLOOR
HEATING
FRIDGE
FREEZER
ENERGY
CENTRE
IN SHOP
GROUND
CIRCUIT
LTO
CO2
18 °C
50%
26 °C
50%
18 °C
100%
9 °C
100%
26 °C
55%
11 °C
+20 °C
+5 °C
+10 °C

FIG. 8A

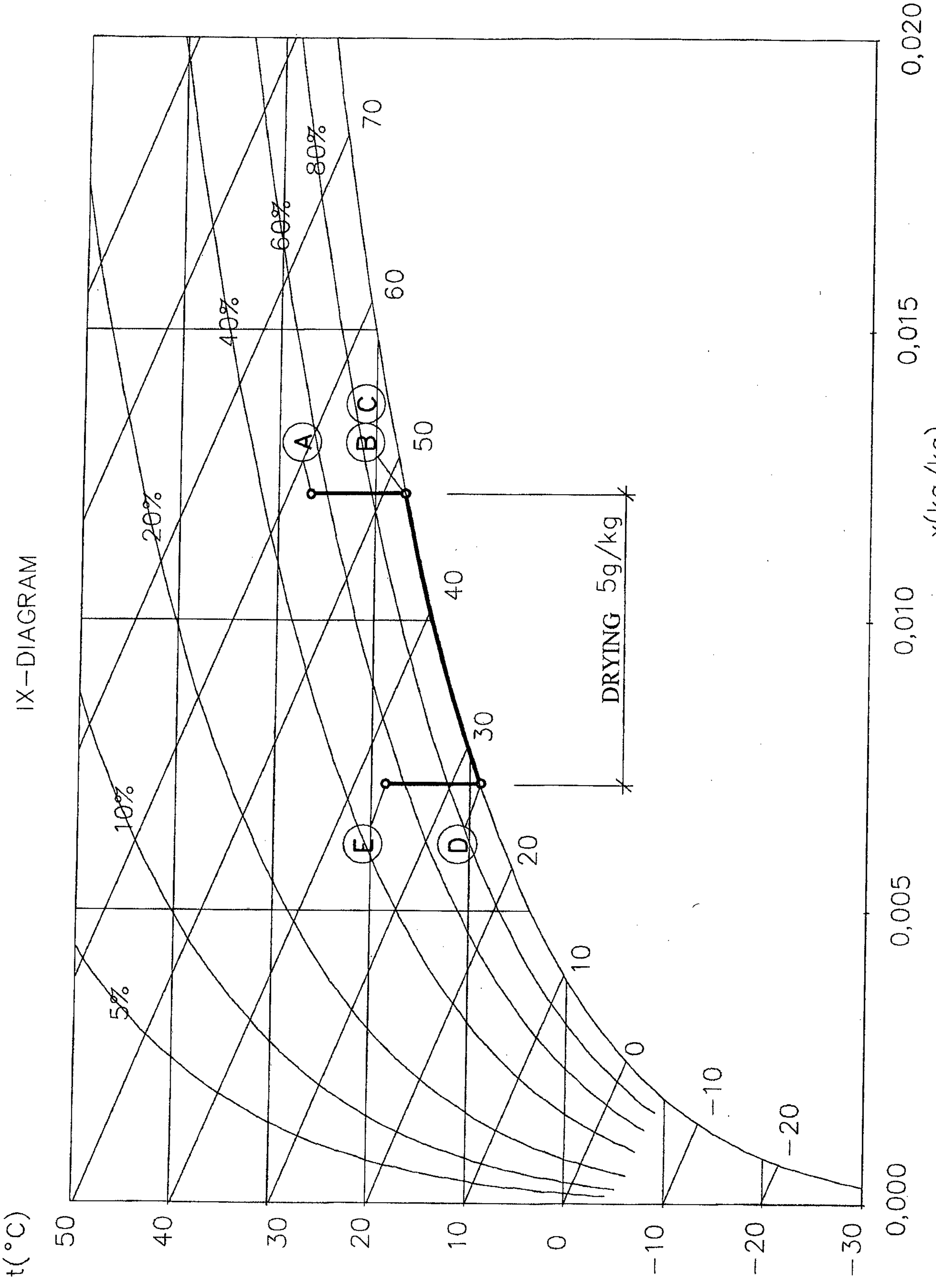
IX–DIAGRAM
t(°C)
x(kg/kg)
DRYING 5g/kg
A
B
C
D
E
5%
10%
20%
40%
60%
80%
70
60
50
40
30
20
10
0
−10
−20
50
40
30
20
10
0
−10
−20
−30
0,000
0,005
0,010
0,015
0,020

FIG. 8B

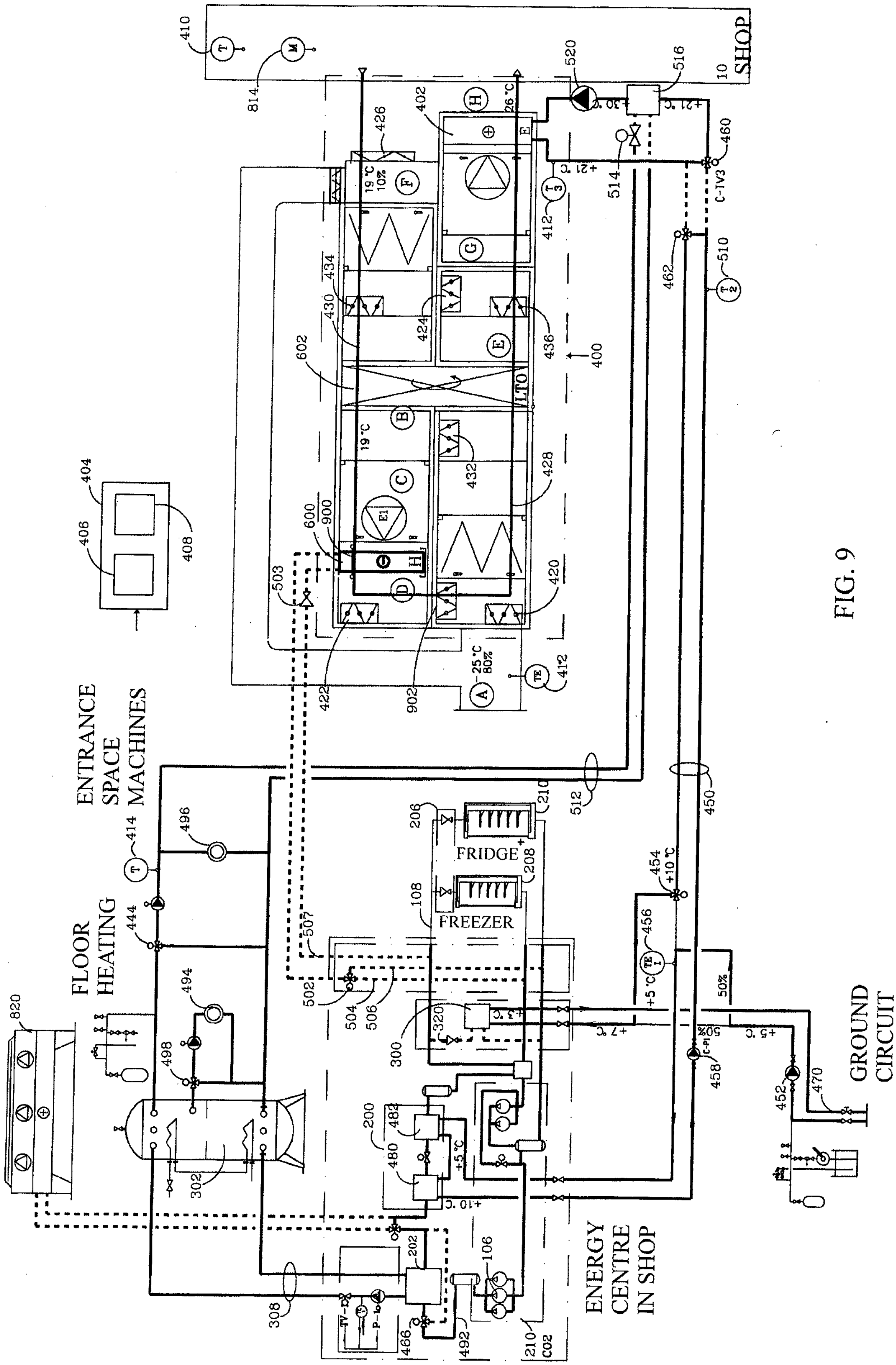
SHOP
ENTRANCE SPACE MACHINES
FLOOR HEATING
FRIDGE
FREEZER
LTO
GROUND CIRCUIT
ENERGY CENTRE IN SHOP

FIG. 9

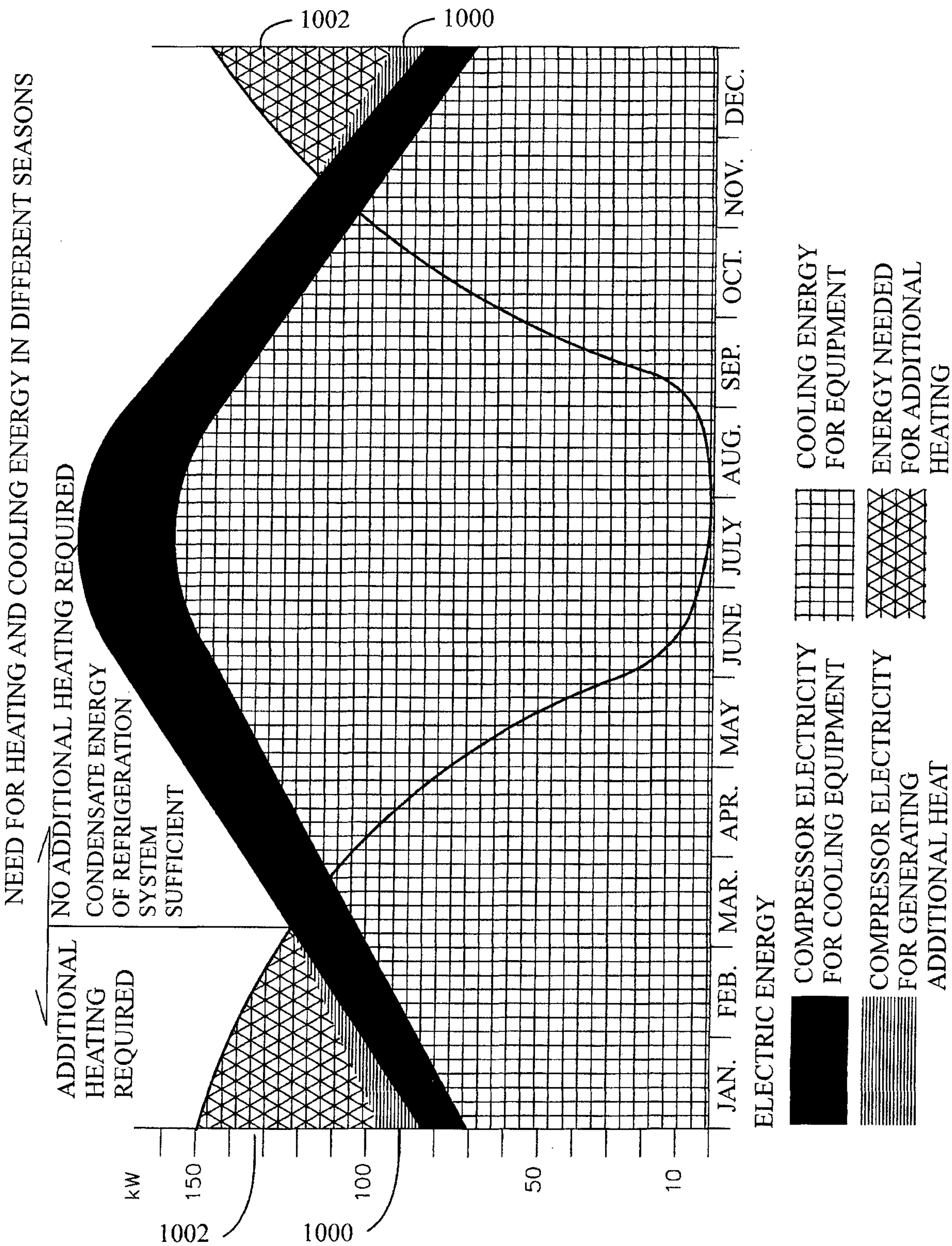
NEED FOR HEATING AND COOLING ENERGY IN DIFFERENT SEASONS
ADDITIONAL HEATING REQUIRED
NO ADDITIONAL HEATING REQUIRED
CONDENSATE ENERGY OF REFRIGERATION SYSTEM SUFFICIENT
1002
1000
kW
150
100
50
10
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEP.
OCT.
NOV.
DEC.
ELECTRIC ENERGY
COMPRESSOR ELECTRICITY FOR COOLING EQUIPMENT
COMPRESSOR ELECTRICITY FOR GENERATING ADDITIONAL HEAT
COOLING ENERGY FOR EQUIPMENT
ENERGY NEEDED FOR ADDITIONAL HEATING

FIG. 10

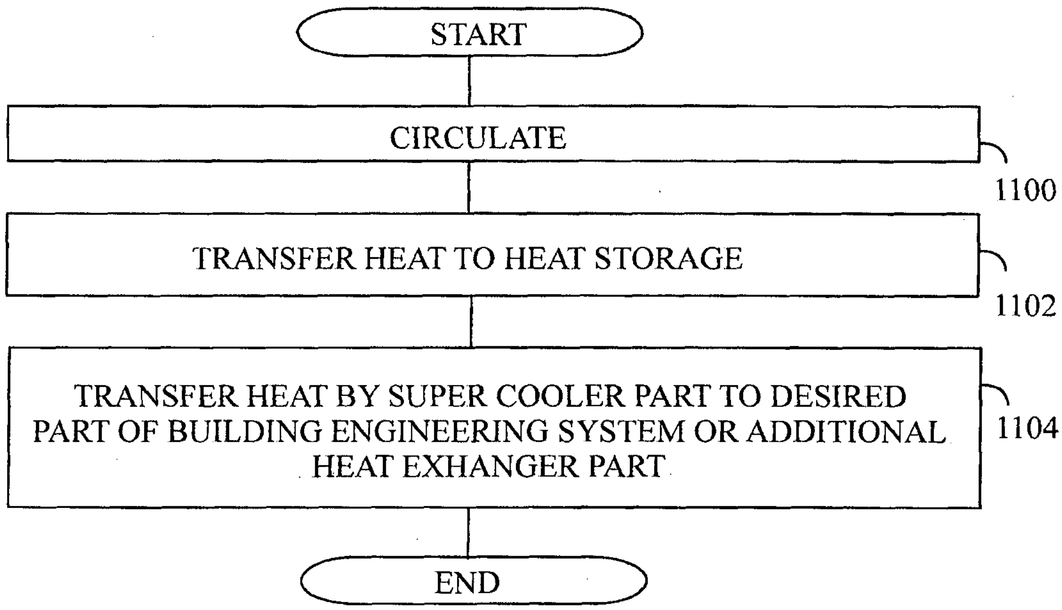
START
CIRCULATE
1100
TRANSFER HEAT TO HEAT STORAGE
1102
TRANSFER HEAT BY SUPER COOLER PART TO DESIRED PART OF BUILDING ENGINEERING SYSTEM OR ADDITIONAL HEAT EXHANGER PART
1104
END

FIG. 11

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050328

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F24D, F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 6164086 A (KITA KOICHI [JP] et al.) 26 December 2000 (26.12.2000) whole document; especially figures 1A, 1B, 5, and 8 | 1-29 |
| A | EP 1923123 A2 (INGERSOLL RAND CO [US]) 21 May 2008 (21.05.2008) whole document | 1-29 |
| A | US 4423602 A (VENABLE BENNETT M [US]) 03 January 1984 (03.01.1984) whole document | 1-29 |

☐ Further documents are listed in the continuation of Box C.  ☒ See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 25 June 2013 (25.06.2013) | 26 June 2013 (26.06.2013) |

| Name and mailing address of the ISA/FI | Authorized officer |
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| Patent document cited in search report | Publication date | Patent family members(s) | Publication date |
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CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
***F25B 29/00*** (2006.01)
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***F25B 41/00*** (2006.01)