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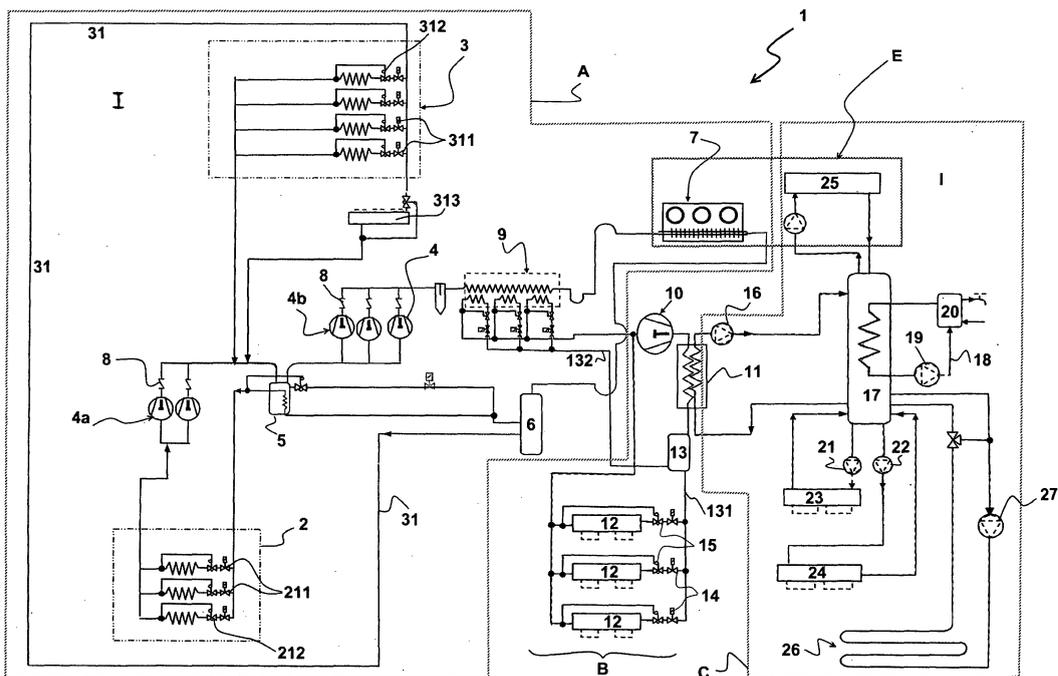
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(54) **Plant and process for producing cold and for producing hot water to be supplied to one or more thermal users**

(57) The invention refers to a thermodynamic process for producing cold for refrigerating users and for producing hot water for thermal users. The thermodynamic cycles for producing cold provides for transferring heat to the water that is collected in a tank to be selectively supplied to one or more thermal users, when necessary based upon the season and the environmental condi-

tions. The heating of the water thus exploits a part of the heat produced by the thermodynamic cycles and that would in any case be lost into the atmosphere. In this way the efficiency is maximised.

The invention also refers to a thermal plant operating according to the aforementioned process, in which the thermodynamic cycles and the circuit for supplying the hot water to the thermal users are configured in cascade.



**FIG. 1**

## Description

**[0001]** The present invention refers to a thermodynamic process for producing cold and for producing hot water to be supplied to one or more thermal users, which has a preferred, although not exclusive, use in rooms wherein it is necessary to conserve frozen or deep-frozen and/or fresh foods, and at the same time air conditioning is needed.

**[0002]** The invention also refers to a thermal plant for producing cold and for producing hot water to be supplied to thermal users, operating according to the aforementioned thermodynamic process.

**[0003]** In many buildings, for example shops such as mini or supermarkets, food shops and similar, and dining establishments such as canteens, restaurants, snack bars and the like, there is a first need to arrange users for conserving foods at a controlled temperature, typically below the temperature of the room in which such users are located. The foods can be fresh, for example meats, fruit, vegetables, dairy products, soft drinks, confectionary or gastronomy products, etc., or even frozen or deep-frozen. The conservation at a controlled temperature can be intended, for example, for the display and sale of the foods, or else for their storage.

**[0004]** To conserve foods, refrigerated counters or cabinets of various shapes and sizes, cold rooms, etc. are commonly used. Irrespective of their type, we shall refer to these apparatuses with the expression "refrigerating users".

**[0005]** The operation of refrigerating users is usually ensured by special plants for producing cold; each plant is associated with a single refrigerating user or else many centralised devices to serve a plurality of refrigerating users. The refrigerating users can be different in number, and/or in type, according to the number or type of units used.

**[0006]** In addition to the production of cold for conserving foods, many applications also provide for controlling the temperature of the air within rooms. In other words there is often a second need, which is to regulate the conditions of the air so as to make it comfortable for employees and customers to stay in the rooms, both during the cold seasons and during the hot seasons. In order to satisfy this requirement special conditioning units, and/or heat pumps, boilers for producing hot water, etc. are commonly used, having the function of regulating the air temperature through heat exchange with a working fluid. Heat pump units can, for example, be "fan-coil" units or similar.

**[0007]** In some circumstances the possibility of installing plants for producing cold together with plants for regulating the air temperature can be limited due to the little space available and/or due to building restrictions. This may be the case, for example, in old buildings in historic city centres.

**[0008]** European patent application EP 08425703.9, to the Applicant, describes a plant comprising a closed

circuit in which a working fluid completes a thermodynamic cycle. The closed circuit provides a plurality of thermal users for regulating the air temperature of a room, for example air conditioners. The same closed circuit also comprises different refrigerating users, and in particular at least one unit for conserving frozen or deep-frozen foods (not necessarily present) and/or at least one unit for conserving fresh foods.

**[0009]** The described plant makes it possible to simultaneously satisfy the dual need to produce cold to conserve foods and to regulate the air temperature of the room, in an efficient way and with a small number of apparatuses. In this plant the users are thus distinguished according to the relative purpose: producing cold to conserve foods, or else producing cold to decrease the air temperature in rooms compared to the outside, during the summer or on hot days.

**[0010]** There is the further need to exploit the described plants to also produce heat, in particular for producing a working fluid having a temperature of above 35° C to supply plants for heating rooms during the cold seasons, or else to supply generic thermal users.

**[0011]** The purpose of the present invention is to provide a thermodynamic process, and the relative thermal plant, for producing cold and for producing a hot working fluid intended to be supplied alternately, selectively or simultaneously to one or more thermal users, which are simple and efficient in terms of energy output.

**[0012]** For the purposes of the present invention, by the expression "thermal users" it is intended to identify the apparatuses and the circuits that for their relative operation must be supplied with a hot working fluid, preferably water, the temperature of which is above 35° C. As an example are considered thermal users the sanitary thermal users of the building that houses the commercial structure (the sinks where the food is washed, prepared or packaged, the bathrooms, the tanks located in the rooms for storing cleaning implements, etc.), the units for heating and dehumidifying the ambient air, the possible floor heating units in rooms, etc..

**[0013]** In accordance with a first aspect thereof, the invention concerns a thermodynamic process according to claim 1.

**[0014]** In particular, the invention, in a first aspect thereof, concerns a thermodynamic process for producing cold for refrigerating users and for producing hot water for thermal users, comprising the steps of:

*aa)* implementing at least one thermodynamic cycle in which a working fluid flows in a closed circuit and supplies at least one unit for conserving frozen or deep-frozen foods, and/or at least one unit for conserving fresh foods, and/or one or more units for cooling the air in a room;

*bb)* providing one or more thermal users to be selectively supplied with hot water,

**characterised in that** the hot water supplied to said ther-

mal users is in heat-exchange relationship with said working fluid and receives heat from the same.

**[0015]** Advantageously, the configuration described in relation to the heat exchange between the working fluid and the water allows to make the most of the the energy sources in the different conditions of use.

**[0016]** In the present description and in the subsequent claims, by the term "room" we mean to generically indicate an enclosed portion of space, and by the term "outside" we mean to generically indicate any space outside of said room, even if possibly located indoors. More specifically, by room we mean to indicate the shop or the dining establishment in which the plant that operates according to the thermodynamic process is installed, irrespective of whether it contains just one or many enclosed spaces.

**[0017]** By the expression closed circuit we mean to indicate the circuit in which a working fluid flows and that extends according to a closed loop in which compressors, refrigerating users, valves, pipes, heat exchangers, etc. are arranged, according to what is provided by the corresponding thermodynamic cycle. Usually, the closed circuits are also sealed, in the sense that leaks of working fluid from the circuit into the atmosphere are prevented.

**[0018]** In the present invention, a working fluid is in heat exchange relationship with another fluid when it exchanges heat with it, for example in a special heat exchanger in which the two fluids in any case remain separate.

**[0019]** Preferably, there are two thermodynamic cycles provided in the aforementioned step *aa*):

- a first thermodynamic cycle in which a first working fluid flows in a corresponding first closed circuit and supplies at least one unit for conserving frozen or deep-frozen foods and/or at least one unit for conserving fresh foods, and
- a second thermodynamic cycle, distinct from the first cycle, in which a second working fluid flows in a corresponding second closed circuit and during the hot seasons it supplies one or more units for cooling the air in a room. The second working fluid is in heat exchange relationship with the first working fluid, and the hot water supplied to the different thermal users is in heat exchange relationship with the second working fluid and receives heat from it, both during the hot seasons, and during the cold seasons.

**[0020]** The energy saving that can be obtained thanks to the described configuration, especially in large commercial areas, is considerable. The excellent utilization of the waste energy of the different circuits and of the compression works also allows the amount of heat given up to the outside to be minimised, thereby minimising the environmental impact of the relative plant.

**[0021]** In a preferred embodiment of the process according to the present invention, the first thermodynamic cycle and the second thermodynamic cycle are refriger-

ating cycles. The first working fluid transfers heat to the second working fluid. In practice, the circuit in which the second working fluid is active is subordinated to the circuit in which the first working fluid is active. The heat exchange between the fluids can be direct, or else it can take place through an intermediary fluid that receives heat from the first fluid and transfers the same to the second fluid. In practice, the second circuit is arranged in cascade with respect to the first circuit.

**[0022]** During the hot seasons, for example in summer time, the second working fluid supplies one or more units for cooling the ambient air. During the cold seasons, for example in winter time, the units for cooling the air are deactivated. For this reason, and as shall be described more clearly hereafter, the heat transferred by the first working fluid to the second working fluid is greater during the cold seasons than the heat transferred during the hot seasons.

**[0023]** Preferably, the second working fluid transfers heat to a water flow rate flowing in a corresponding third closed circuit subordinated to the second circuit, in cascade. The heat exchange with the second working fluid causes an increase in the temperature of the water flow rate that flows in the third circuit, preferably to the heat levels at which condensation boilers operate, for example for common boilers over 35°C and more preferably between 40°C and 55°C, according to the season. The water flow rate thus heated is collected in a collection tank, which directly or indirectly supplies one or more thermal users. The extent of the heat exchange between the second working fluid and the water flow rate varies according to whether the units for cooling the ambient air are active or not. In particular, the heat transferred by the second working fluid to the water flow rate flowing in the third circuit is greater during the cold seasons than the heat transferred during the hot seasons. This characteristic allows hot water to be made available when it is needed most.

**[0024]** In a first operating mode, the step of implementing the first thermodynamic cycle in turn comprises the steps of:

- a) compressing the first working fluid;
  - b) putting the first working fluid in heat exchange relationship with the second working fluid and transferring heat to the second working fluid in one or more heat exchangers;
  - c) substantially completing the condensation of the first working fluid when necessary based upon the heat exchange conditions with the second working fluid;
  - d) expanding and evaporating at least one part of the first working fluid at at least one unit for conserving frozen or deep-frozen foods and/or at at least one unit for conserving fresh foods.
- The step of implementing said second thermodynamic cycle in turn comprises the steps of:
- e) compressing the second working fluid and placing

the same in heat exchange relationship with the water flow rate flowing in the third circuit, transferring heat to it, and

f) optionally, during the hot seasons, expanding and evaporating at least one part of the second working fluid at at least one unit for cooling the ambient air.

**[0025]** In this first operating mode, during step *d)* the first working fluid substantially absorbs the heat transferred during said steps *b)* and *c)* and during step *b)* the second working fluid substantially absorbs the heat transferred during steps *e)* and *f)*. In other words, the first, second and possible third thermodynamic cycle are configured in cascade, with the third cycle subordinated to the second cycle and the second cycle subordinated to the first cycle.

**[0026]** In a second operating mode, which can be associated with the cold seasons, the units for cooling the air can be selectively deactivated. This characteristic allows one or more units for cooling the air to be excluded when necessary based upon the environmental conditions. In this circumstance, in step *b)* the second working fluid substantially absorbs the heat transferred during step *e)*.

**[0027]** Preferably, the thermal users of the third circuit comprise at least one unit for heating the air in the room, and/or at least one unit for dehumidifying the air in the room, one or more heating systems positioned in the floor of a room and one or more circuits for distributing water for sanitary use. The hot water is selectively supplied to one or more of said thermal users simultaneously. Such thermal users can be selectively deactivated when there is no need to heat or dehumidify the air, or heat the floor or the water for sanitary use, or even when the units for cooling the air are operating.

**[0028]** Preferably, the water for sanitary use is heated to a temperature equal to about 35-40°C, i.e. that which is commonly adopted in condensation boilers.

**[0029]** Preferably, the circuit for distributing the water for sanitary use is placed in heat exchange relationship with the hot water contained in the collection tank.

**[0030]** Preferably, step *a)* of the first thermodynamic cycle in turn comprises compressing a first flow rate of the first working fluid, suitable for ensuring the operation of the units for conserving frozen or deep-frozen foods, and compressing a second flow rate of the first working fluid, suitable for ensuring the operation of the units for conserving fresh foods.

**[0031]** In accordance with a second aspect thereof, the present invention concerns a thermal plant according to claim 11.

**[0032]** In particular, the thermal plant comprises:

- at least one closed circuit in which flows a corresponding working fluid that undergoes a thermodynamic cycle and supplies at least one unit for conserving frozen or deep-frozen foods, and/or at least one unit for conserving fresh foods, and/or at least

- one unit for cooling the air in a room, and
- a closed circuit for circulating hot water and one or more thermal users that can be selectively supplied with said hot water, and it is

**characterised in that** said circuit for circulating the hot water is subordinated in cascade to said circuit for circulating said working fluid.

**[0033]** Preferably, the plant comprises:

- a first closed circuit in which flows a first working fluid that undergoes a first thermodynamic cycle and supplies at least one unit for conserving frozen or deep-frozen foods and/or at least one unit for conserving fresh foods, simultaneously or alternately, and
- a second closed circuit in which flows a second working fluid that completes a second thermodynamic cycle and, during the hot seasons, supplies at least one unit for cooling the air in a room, and
- a third closed circuit, in which flows a water flow rate, comprising one or more thermal users that can be selectively supplied with hot water. The first, second and third circuit are arranged in cascade, with said third circuit being subordinated to said second circuit and said second circuit being subordinated to said first circuit.

**[0034]** The thermal plant according to the present invention advantageously makes it possible to satisfy the requirements of producing cold and of regulating the temperature of the air with the related thermodynamic cycles and, in addition, makes it possible to satisfy the requirement of producing hot water intended to supply different thermal users, through the utilization of the waste energy of the first thermodynamic cycle, i.e. by exploiting part of the heat collected by the first working fluid in the refrigerating users, the compression and the waste energy of the second working fluid, i.e. by exploiting part of the heat collected by the fluid that supplies the units for cooling the ambient air. The water is indeed heated with part of the heat transferred by the second working fluid.

**[0035]** The circuits of the plant share corresponding heat exchangers, in practice being arranged in cascade. The number of components of the plant is therefore less than the number of components of distinct (separate) plants intended for producing cold, for conditioning the air and for heating water. Therefore, both the overall bulk of the plant and the interventions necessary for its installation and maintenance are reduced. This is particularly advantageous in the case of small rooms and/or rooms located in old buildings, in which there can be a limited possibility of carrying out structural work to install plants. Moreover, the use of a single plant according to the present invention for producing cold, for conditioning and for producing hot water to serve different thermal users advantageously allows great flexibility of operation of the individual units of which it consists.

**[0036]** Preferably, each unit for conserving frozen or

deep-frozen foods is a counter, a cabinet or a cold room at a temperature of between about  $-14^{\circ}\text{C}$  and about  $-30^{\circ}\text{C}$ . In particular, such a temperature is preferably between about  $-14^{\circ}\text{C}$  and about  $-16^{\circ}\text{C}$  in the case of conservation of frozen foods. This temperature is preferably equal to or less than about  $-18^{\circ}\text{C}$  in the case of deep-frozen foods and it is preferably close to about  $-30^{\circ}\text{C}$  in the case of the conservation of industrial ice-cream.

**[0037]** Preferably, each unit for conserving fresh foods is a counter, a cabinet or a cold room at a temperature of between about  $+10^{\circ}\text{C}$  and about  $-1^{\circ}\text{C}$ . In particular, such a temperature is preferably between about  $+8^{\circ}\text{C}$  and about  $+6^{\circ}\text{C}$  in the case of the conservation of fruit and vegetables. This temperature is preferably between about  $+5^{\circ}\text{C}$  and about  $+3^{\circ}\text{C}$  in the case of the conservation of dairy products and cold meats and it is preferably between about  $+2^{\circ}\text{C}$  and about  $0^{\circ}\text{C}$  in the case of the conservation of meat, poultry and fish.

**[0038]** Preferably, the room to which we have referred is a shop at least in part intended for the sale of food, or else a dining establishment.

**[0039]** In a preferred embodiment the first working fluid at least partially evaporates in the units for conserving frozen or deep-frozen foods, and in the units for conserving fresh foods, absorbing heat. In other words, the aforementioned units are hydraulically connected with the first closed circuit of the thermal plant, at as many refrigerating delivering points, and they operate directly with the first working fluid. The production of cold at such units takes place by direct expansion of the first working fluid, to the great advantage of the simplification of the plant and the efficiency of the aforementioned units.

**[0040]** In alternative embodiments it is nevertheless possible for the units for conserving frozen or deep-frozen foods, and/or the unit for conserving fresh foods to operate with a heat transfer fluid, preferably a non-freezing heat transfer fluid, distinct from the first working fluid and placed in heat exchange relationship with it. In this case, the units are inserted into one or more secondary circuits hydraulically separate from the first closed circuit of the thermal plant and in heat exchange relationship with it at one or more heat exchange elements, in said points where refrigeration is required.

**[0041]** Preferably, the first closed circuit comprises a heat exchange device at which the first working fluid is in heat exchange relationship with the outside of the aforementioned room. The heat exchange device comprises a condensing portion, at which the first working fluid transfers heat to the air of the outside. The extent of the heat exchange of the first working fluid with the outside air depends mainly upon the amount of heat transferred downstream of the second working fluid. As the heat transferred by the first working fluid to the second working fluid increases the heat transferred by the first working fluid to the outside air decreases.

**[0042]** In addition to the aforementioned refrigerating users, the first circuit comprises a plurality of compressors for circulating the first working fluid, a first group of

compressors having a refrigerating capacity suitable for ensuring the operation of the units for conserving frozen or deep-frozen foods, and a second group of compressors having a refrigerating capacity suitable for ensuring the operation of the units for conserving fresh foods.

**[0043]** The operation of each unit for conserving frozen or deep-frozen foods is thus ensured by the first group of compressors dedicated to them. Such units can therefore be managed, and possibly excluded, by the first closed circuit of the thermal plant, without substantially influencing the performance of the other units. Similarly, the operation of the units for conserving fresh foods, on the other hand, is ensured by a relative second group of compressors. This, in the case of failure of one of the compressors of a group, makes it possible to continue to ensure the operation of the units supported by the compressors of the other group, at least within certain limits.

**[0044]** Should the plant being provided with a first and second circuit for separately supplying the refrigerating units and the units for cooling the air, the first circuit comprises at least one other heat exchanger, shared with the second circuit. The second working fluid is in heat exchange relationship with the first working fluid at one or more heat exchangers shared between the first circuit and the second circuit of the plant (circuits in cascade). Such an exchanger comprises a condensing portion, in which the first working fluid transfers heat, and an evaporating portion, in which the second working fluid can at least partially, and preferably substantially, absorb the heat transferred at the condensing portion.

**[0045]** The second circuit comprises one or more units for cooling the air in the surrounding area. Preferably, these are air conditioners or cold batteries for air treatment units. Such units can be selectively deactivated during the cold seasons, for example in winter time when it is not necessary to condition the rooms.

**[0046]** In an embodiment of the plant according to the present invention the second working fluid operates directly in the unit for cooling the air.

**[0047]** In an alternative preferred embodiment the unit for cooling the air operates with its own heat transfer fluid, for example water, distinct from the second working fluid and in heat exchange relationship with it. In this circumstance the units for cooling the air are preferably inserted in secondary circuit hydraulically separate from the second closed circuit of the plant. The secondary circuit is placed in heat exchange relationship with the second circuit at one or more heat exchange elements, i.e. in one or more points where refrigeration is required.

**[0048]** In this preferred embodiment, the heat transfer fluid flowing in the unit for cooling the air, when operating, can be advantageously kept at a positive temperature. This substantially avoids the formation, at the heat exchange battery of such a unit, of brine that, since it is thermally insulating, would hinder the heat exchange with the air of the room. A more comfortable climate is also obtained, since the temperature of the air emitted by the unit compared to the temperature of the room can be

better controlled, therefore reducing the risk to people of thermal shocks.

**[0049]** Preferably, the thermal plant comprises selective deactivation means of one or more units for conserving fresh foods, and/or one or more units for conserving frozen or deep-frozen foods, and/or one or more units for cooling the air in a room. Such deactivation means can, for example, comprise at least one valve for intercepting a portion of the first circuit or of the second circuit and a corresponding by-pass circuit of the relative working fluid.

**[0050]** In addition to the units for cooling the air, the second circuit comprises at least one compressor for circulating the second working fluid. The compressor has a refrigerating capacity sufficient to ensure the operation of the units for cooling the air or in any case sufficient to support the heat exchange of all of the heat transferred between the fluids in the exchanger. Advantageously, part of the compression work, which determines an increase in the energy of the second working fluid, is recovered to heat the water in the third circuit.

**[0051]** Preferably, both the first and the second circuit of the plant comprise expansion means of the respective working fluids, selected from thermal expansion valves and/or flooding supply systems of the evaporators.

**[0052]** Preferably, the first working fluid and the second working fluid are refrigeration fluids selected from the group comprising hydrofluorocarbons (HFC), hydrochlorofluorocarbons (HCFC), carbon dioxide, propane, ammonia or other known technical fluids. More preferably, such refrigeration fluids are hydrofluorocarbons (HFC) selected from the group comprising R-507 A, R-134 a, R-410, R-404 A, R-407C. The third working fluid is preferably demineralised water with added antifreeze or any non-freezing mixture like, for example, formates, acetates or nanoparticles.

**[0053]** Alternatively, the second working fluid is carbon dioxide CO<sub>2</sub>.

**[0054]** Preferably, the third closed circuit comprises:

- at least one first heat exchanger, shared with said second circuit, in which the flow rate of flowing water receives heat from the second working fluid, and
- at least one collection tank, supplied with the water flow rate heated to a temperature typical of condensation boilers, for example over 35°C, incoming from the first heat exchanger.

**[0055]** The thermal users of the third circuit are supplied directly with hot water taken from the collection tank, or else they are supplied with a corresponding working fluid placed in heat exchange relationship with the hot water collected in the tank.

**[0056]** The third working fluid is placed in circulation in the corresponding circuit by one or more pumps.

**[0057]** The thermal users of the third circuit are selected from a unit for heating ambient air, a unit for dehumidifying the ambient air, one or more panels arranged to

heat a floor in said room and a circuit for distributing water for sanitary use.

**[0058]** Preferably, the thermal plant comprises a microprocessor control unit programmed to control the operation of the plant in feedback, based upon the required operating conditions at:

- said at least one unit for cooling the air in the room, and
- said at least one from a unit for conserving frozen or deep-frozen foods and a unit for conserving fresh foods, and
- said at least one unit for heating the air in the room or said at least one unit for dehumidifying the air in the room or said one or more panels for heating the floor, and
- said circuit for distributing water for sanitary use.

**[0059]** Preferably, the water collected in the collection tank has a temperature characteristic of condensation boilers, typically over 35°C. The water is preferably mixed with glycols (20% by mass).

**[0060]** Preferably, the thermal plant of the invention comprises means for switching between the different operating modes. The thermal plant of the invention can therefore be used to regulate the temperature of the air both in the hot seasons and in the cold seasons, substantially without the operation of the units for conserving foods being jeopardised.

**[0061]** Preferably, the switching means comprise a microprocessor control unit, suitably programmed to control the intercepting means of portions of the circuits of the plant.

**[0062]** The operation of the plant is as follows.

**[0063]** During the hot seasons, for example in the summer, at least one of the thermal refrigerating devices of the first circuit for conserving foods is active; the units for cooling the ambient air are also active, i.e. they are supplied with the second working fluid. The first working fluid condenses in the exchanger of the first circuit positioned outside of the room. At the heat exchanger shared between the second and the third circuit, the second working fluid transfers heat to the water flow rate flowing in the third circuit. The water, heated to a temperature characteristic of condensation boilers, typically above 35°C, is collected in the tank of the third circuit and preferably supplies the unit(s) for dehumidifying the air and transfers heat to the water for sanitary use flowing in the relative distribution circuit. The unit for heating ambient air is deactivated. Preferably, the panels for heating the floor are deactivated, but optionally it is possible to activate one or more panels to dry the floor that has been made wet by customers of the shop on rainy days or else to heat the floor in the till area of the shop.

**[0064]** During the cold seasons, for example in winter time, the refrigerating users of the first circuit for conserving foods are active; the units for cooling the ambient air are deactivated, i.e. they are not supplied with the second

working fluid. The first working fluid transfers heat to the second working fluid at the heat exchanger shared between the first and the second circuit. At the heat exchanger shared between the second and the third circuit, the second working fluid substantially transfers the heat received from the first working fluid to the water flow rate flowing in the third circuit. The water thus heated is collected in the tank of the third circuit and preferably supplies the unit(s) for heating the air in the room and/or the panels arranged in the floor and gives up heat to the water for sanitary use flowing in the relative distribution circuit. The unit for dehumidifying the air is activated when needed.

**[0065]** Further characteristics and advantages of the present invention shall become clearer from the following detailed description of a preferred embodiment thereof, made with reference to the attached figures 1 and 2 that respectively show a block diagram of two embodiments of the thermal plant according to the invention.

**[0066]** In figure 1 a thermal plant in accordance with the invention for producing cold to conserve foods, to cool the air and to produce hot water to supply different thermal users is wholly indicated with reference numeral 1. The same plant 1 allows the thermodynamic process according to the present invention to be described.

**[0067]** The thermal plant 1 is preferably applied in a room I where it is necessary to conserve fresh and/or frozen/deep-frozen foods, for example for the purpose of selling (retail or wholesale), or for catering. Such applications comprise shops such as mini or supermarkets, food shops and similar, and dining establishments such as canteens, restaurants, snack bars and similar.

**[0068]** The thermal plant 1 comprises a first closed circuit A in which a first working fluid undergoes a first thermodynamic cycle, a second closed circuit B, subordinated to the first circuit A, in which a second working fluid undergoes a second thermodynamic cycle, and a third closed circuit C in which flows hot water, or a mixture of water and glycols (or other technical mixtures), to supply different thermal users.

**[0069]** The first circuit A shall now be described in detail. The circuit A comprises a plurality of refrigerating delivering points at which at least one unit for conserving foods is arranged. In particular, the first circuit A comprises at least one refrigerating user selected from a unit 2 for conserving frozen or deep-frozen foods and a unit 3 for conserving fresh foods. Preferably, the plant has many units 2 in arrays, i.e. arranged in parallel on the same line, and many units 3 in batteries. The units 2 and 3 can, for example, be refrigerated counters or cabinets, or else cold rooms. In figure 1 the numbers 2 and 3 identify batteries of refrigerating users.

**[0070]** Preferably, the units 2 and 3 are hydraulically connected in the closed circuit A and operate through direct expansion of the first working fluid. More preferably, the batteries of units 2 are arranged on distinct lines of the closed circuit A with respect to the batteries of units 3, so that a failure or a maintenance intervention on a

line does not simultaneously jeopardise the operation of both the batteries of units 2, 3.

**[0071]** In the units 2 for conserving frozen or deep-frozen foods the first working fluid on average is at a lower temperature (conventionally "low temperature") than the same fluid in the units 3 for conserving fresh foods (conventionally "normal temperature"). As an example, the temperature of the first working fluid at a unit 2 for conserving frozen or deep-frozen foods is typically between about -42°C and about -20°C. The temperature of the first working fluid at a unit 3 for conserving fresh foods is typically between about -15°C and about +2°C.

**[0072]** The first circuit A comprises at least one compressor having the function of circulating the first working fluid according to the flow rates and the pressures suitable for the relative refrigerating cycle. In the illustrated embodiment the plant 1 comprises five compressors 4 divided into two groups of compressors 4a and 4b, respectively comprising two and three compressors. The compressors 4 can, for example, be of the hermetic, semi-hermetic or open type, and, in relation to the way in which the compression is carried out, using pistons, screw or scroll or more generically rotary.

**[0073]** The refrigerating capacity of the compressors 4 can be the same for all of the compressors, or different for some or each of them or adjustable through partialisation of the heads and/or through the variation of the number of revolutions of the relative electric motor.

**[0074]** The intake of the compressors 4 of the group of compressors 4a is connected with the output line from the units 2 for conserving frozen or deep-frozen foods. Downstream of the compressors 4a with respect to the running direction of the fluid, the line arriving from the units 3 for conserving fresh foods converges. Downstream of this convergence there is preferably an anti-liquid bottle equipped with internal heat exchanger 5, and a lamination system of the coolant; the whole assembly works as an intercooler, in turn in connection with a tank 6 for collecting the first working fluid. The tank 6 directly supplies the units 3 by means of the line 31.

**[0075]** Preferably, as shown in figure 1, downstream of the units 3 an evaporator 313 is provided, having the function of making it easier to start up the plant 1 during the cold seasons, after being switched off a prolonged period.

**[0076]** Downstream of the exchanger 5 there is the intake of the compressors 4 of the group of compressors 4b. The compressors 4b send the working fluid to a heat exchange device 7, at which the working fluid is in heat exchange relationship with the outside E of the room I.

**[0077]** The heat exchange device 7 preferably consists of an assembly arranged outside E of the room I inside which the units 2 and 3 are active, preferably outside of the building comprising the room I. The heat exchange device 7 allows the heat exchange of the first working fluid with the air or other fluid available outside E, like water (for example, according to availability and/or requirements, river water, aquifer water, runoff water) or

another suitable fluid.

**[0078]** Preferably, the heat exchange device **7** also comprises means for the forced circulation of air or of another fluid available outside and of the conventional type, such as one or more fans, for example of the helical or centrifugal type, typically electrically actuated. Such means are arranged so as to increase the air flow through the heat exchange device **7** in a preferred direction.

**[0079]** Between the group of compressors **4b** and the heat exchange device **7** there is a heat exchanger **9** with the second working fluid. The exchanger **9** can in turn comprise one or more heat exchange units. At the exchanger **9** the first working fluid in part transfers heat to the second working fluid. In this circumstance the first fluid can undergo a partial condensation. The exchanger **9** is shared between the first circuit **A** and the second circuit **B**.

**[0080]** Downstream of the heat exchange device **7** the first working fluid is conveyed into the collection tank **6**, at which the circuit **A** closes.

**[0081]** Downstream of each compressor **4** a conventional check valve **8** and means for separating and recovering oil of the compressors **4** dispersed in the working fluid are preferably arranged. Such means can, for example, comprise an oil separator, filters and a recovery line for the separated and filtered oil.

**[0082]** The second closed circuit **B** shall now be described in detail, in which a second working fluid undergoes a second thermodynamic cycle. The second closed circuit **B** shares the heat exchanger **9** with the first circuit **A** to which it is subordinated. At the exchanger **9** the first working fluid and the second working fluid are in heat exchange relationship. In particular, the exchanger **9** comprises a condensing portion, at which the first working fluid undergoes a partial or total condensation and releases heat, and an evaporating portion, separate and distinct from the condensing portion, in which the second working fluid heats up substantially accumulating the heat released by the first working fluid. Preferably, the exchanger **9** comprises one or more evaporating sections and means for selectively excluding one or more of such portions. The exclusion of one or more evaporating portions is used to limit the amount of heat transferred to the second working fluid when necessary based upon the operating conditions of the plant **1**.

**[0083]** In the embodiment shown, the first circuit **A** and the second circuit **B** are hydraulically separate.

**[0084]** The second circuit **B** also comprises a compression section, in which there is at least one compressor **10** (in practice a heat pump), as shown in figure 1, for the forced circulation of the second working fluid. The second working fluid leaving the exchanger **9** is sent to a further exchanger **11** shared with a third closed circuit **C**, as shown in figure 1. At the exchanger **11** the second working fluid transfers heat to a water flow rate that flows in the third circuit **C**.

**[0085]** Downstream of the exchanger **11** with respect to the direction of the circulation of the second working

fluid a tank **13** for collecting the fluid is preferably provided. More preferably, such a tank is of the stratified type. The tank **13**, in delivery, serves a line **131** and a line **132**. As shown in figure 1, the line **132** supplies the exchanger **9** shared with the first circuit **A**. The line **131** supplies one or more units **12** for cooling the air in the room **A**. Each unit **12** represents a point where refrigeration is required of the second circuit **B**, at which the second working fluid is at a temperature suitable for the heat exchange with at least the corresponding unit **12**. Preferably, the units **12** are cold batteries for air treatment units. The overall cooling power delivered by the units **12**, measured in kW, is established at the design step and depends upon the size of the room **I**, upon the degree of insulation of the building, upon the number and heat sources present in it and upon the average number of people located in the room **I**.

**[0086]** During the summertime the air temperature of the room **I** must be able to be regulated at about 25°C, typically when the room **I** is cooled. In this circumstance the second working fluid at the units **12** must have a temperature equal to about +7°C.

**[0087]** The second circuit **B** preferably comprises interception means **14**, for example solenoid valves, arranged to allow the activation or exclusion of the individual units **12** both during normal operation, for example to carry out adjustments to the plant **1** according to the season, and in conditions of failure or of partial shut-down of the same plant **1**. The interception means are preferably controlled remotely by a control unit of the plant **1**.

**[0088]** The circuit **B** preferably also comprises expansion means **15** of the second working fluid. Such means **15** are preferably conventional, for example mechanical or electronic thermal expansion valves, or flooding systems of the evaporator, but more preferably thermal expansion valves. The valves **15** are arranged at the points where refrigeration is required, i.e. at the units **12**, as shown in figure 1.

**[0089]** The second working fluid output from the units **12** is sent to the compressor **10** (the circuit **B** is in a closed loop).

**[0090]** Preferably, the first and second working fluid are refrigeration fluids, for example hydrofluorocarbons (HFC) known by the name ASHRAE R-507 A, R-134 a, R-410, R-404 A, R-407C.

**[0091]** Alternatively, the second working fluid can be CO<sub>2</sub>, ammonia or any other coolant known in the field.

**[0092]** The plant **1** comprises a third closed circuit **C** in which flows a water flow rate, or a mixture of water and glycols (or another technical fluid) heated by the second working fluid. The third circuit **C** comprises a tank for collecting the hot water and one or more thermal users **18, 23, 24, 26** selectively served with the hot water.

**[0093]** The third circuit **C** shares the exchanger **11** with the second circuit **B**, to which it is subordinated in cascade. At the exchanger **11** the water flowing in the third circuit **C** receives heat from the second working fluid. Despite this, the third circuit **C** is hydraulically separate

from the second circuit **B**.

**[0094]** The third circuit **C** comprises at least one pump **16** for circulating the water. The water, heated in the exchanger **11**, is sent by the pump **16** to a collection tank **17**, in which it is preferably at a temperature typical of condensation boilers, for example above 35°C.

**[0095]** One of the thermal users of the third circuit **C** is a circuit **18** for distributing water for sanitary use. The circuit **18** supplies thermal users external to the plant **1**, for example showers, taps, baths, etc., and it is arranged in heat exchange relationship with the water contained in the tank **17**, as shown in figure 1.

**[0096]** A tank **20** can be arranged along the outer line **18**, downstream of a pump **19** for circulating the water, as shown in figure 1, to collect the water before delivery to the relative thermal sanitary devices.

**[0097]** Two pumps **21** and **22** take the hot water from the tank **17** and send it to corresponding thermal users; in particular they send it to at least one unit **23** for heating the air in the room **I** and at least one unit **24** for dehumidifying the air in the room **I**. In such units **23** and **24** the water is in heat exchange relationship with the air of the room **I**. The water output from the units **23** and **24**, after having heated and/or dehumidified the air, is sent back to the collection tank **17**. From the tank **17** a delivery side sends a water flow rate into the exchanger **11**, closing the cycle.

**[0098]** Optionally, the third circuit **C** also comprises another thermal user consisting of one or more heating units using heating panels **26** arranged in a floor of the room **I**. The diagram shown in figure 1 shows a unit with panels **26** supplied by a corresponding pump **27** and by a three-way valve with fixed point temperature adjustment with hot water taken from the tank **17**. The panels **26** allow a floor made wet by the shoes of customers in the shop to be quickly dried during wet days or allow some points of the supermarket to be heated more, like for example, at the till area.

**[0099]** The third circuit **C** also comprises means for selectively excluding units **23**, **24** and **26**, for example in the summer or else during maintenance of the third circuit **C**. Such means are preferably controlled by a control unit of the plant and can, for example, be interception valves provided upstream of the pumps **21**, **22** and **27**.

**[0100]** The third circuit **C** preferably comprises a heat exchanger **25**, installed outside **E** of the room **I**, having the function of cooling the water contained in the tank **17**, giving up heat to the outside air, when necessary following excessive heating. For example, the exchanger **25** is used in the summer when the thermal users **23**, **24** and **26** are deactivated and the water collected in the tank **17** can reach high temperatures, for example 55°C.

**[0101]** We shall now describe the operation of the thermal plant **1**, in accordance with a preferred embodiment of the thermodynamic process of the invention.

**[0102]** During the cold seasons, for example in mid-winter, the first thermodynamic cycle is active for producing cold at the units **2** for conserving frozen or deep-

frozen foods and at the units **3** for conserving fresh foods; the second thermodynamic cycle is active, i.e. the compressor (or the compressors) **10** is switched on, to circulate the second working fluid, to receive heat from the first working fluid, compress it and transfer heat to the water flowing in the third circuit **C**; the heated water is supplied to the thermal users **23** and/or **24** and/or **26** and/or **18**; the units **12** for cooling the air are excluded, i.e. switched off. The heat given up by the first working fluid to the outside air through the exchanger **7** is minimal. The plant **1** can be made easier to start in the winter by temporarily actuating the evaporator **31**.

**[0103]** During the hot seasons, for example in mid-summer, the first thermodynamic cycle is active for producing cold at the units **2** for conserving frozen or deep-frozen foods and at the units **3** for conserving fresh foods; the second thermodynamic cycle is active, i.e. the compressor **10** is switched on, to supply the units **12** for cooling the air and to transfers heat to the water flowing in the third circuit **C**; the water heated in the third circuit **C** is supplied to the circuit **18** for distributing sanitary water and possibly to the units **24** for dehumidifying the air in the room **I**. The other thermal users **23** and **26** are excluded, i.e. switched off. The heat given up by the first working fluid to the outside air through the exchanger **7** is minimal. If the water of the third circuit heats to above the predetermined value, for example over 55°C, the exchanger **25** is activated to give up heat to the outside air and cool the water collected in the tank **17**.

**[0104]** During the intermediate seasons, for example in late spring or at the start of autumn, it may not be necessary to control the condition of the air in the room **I**. In this case it is possible to exclude the second circuit **B** and the third circuit **C**, i.e. it is possible to switch off the compressor **10** (the second working fluid does not flow in the relative circuit and the exchanger **9** is inactive) and the pump **16** (the water does not flow). The heat transferred by the first working fluid to the outside air through the exchanger **7** is high.

**[0105]** In detail, the first thermodynamic cycle comprises the steps of:

- a) compressing the first working fluid in the compressors **4a** and **4b**;
- b) placing the first working fluid in heat exchange relationship with the second working fluid in the heat exchanger **9** and transferring heat to the second working fluid;
- c) when necessary based upon the operating and heat exchange conditions between the working fluids, substantially completing the condensation of the first working fluid in the exchanger **7** positioned outside **E** of the room **A**;
- d) expanding and evaporating at least a part of the first working fluid at the units **2** and **3**. The step of making the second thermodynamic cycle in turn comprises the steps of:
- e) compressing the second working fluid in the com-

pressor **10** and placing the same fluid in heat exchange relationship with the water that flows in the third circuit **C**, transferring heat to the same,  
 f) during the hot seasons, expanding and evaporating at least a part of the second working fluid at at least one unit **12** for cooling the air in the room **I**.

**[0106]** Advantageously, given that the first circuit **A** and the second circuit **B** are configured in cascade, during step d) the first working fluid substantially absorbs the heat transferred during said steps b) and c) and during step b) the second working fluid substantially absorbs the heat transferred during steps e) and f).

**[0107]** When the units **12** for cooling the air are switched off (valves **14** closed), for example in the winter when it is not necessary to cool the air of the room **I**, during step b) the second working fluid substantially absorbs the heat given up during step e).

**[0108]** Both the changes in operating modes, and the adjustment of the thermal plant **1** between the various seasons are preferably controlled by a specially programmed microprocessor control unit (not shown in the figures).

**[0109]** In particular, the control unit receives the following signals in input:

- pressure at the intake of the compressors **4a** and **4b** of the group of compressors **4**;
- pressure at the intake of the compressor **10**;
- temperature of the room **I**;
- temperature required by the user in the room **I**;
- temperature of the working fluids in various points of the respective circuits **A**, **B**, **C** and of the water for sanitary use in the circuit **18**;
- position of the valves **8**, **14**;
- status of the pumps **16**, **19**, **21**, **22**.

**[0110]** Based upon the signals received, the control unit adjusts the thermal plant **1** in feedback, modifying the number of unit **2**, **3**, **12**, **23**, **24** and **26** to activate or deactivate and acting upon the valves **8**, **14** and upon the pumps **16**, **19**, **21**, **22** and **27**.

**[0111]** Preferably, the thermal plant **1** is intended to be sold without the thermal users (units **2**, **3**, **12**, **23**, **24** and **26**). The different units can indeed be purchased on the market from various suppliers.

**[0112]** The thermal plant **1** is characterised by high energy efficiency. The heat that in other plants would be released into the atmosphere, in the plant **1** is exploited in the circuits **B** and **C** subordinated to the circuit **A**.

**[0113]** Figure 2 shows an alternative embodiment of the plant **1** according to the present invention. In particular, the same reference numerals as those used in figure **1** indicate identical or equivalent elements. Unlike the solution shown in figure **1**, the plant does not provide two distinct circuits **A** and **B** to supply the units for conserving foods and the units for cooling the air. Instead, there is a single closed circuit **D** in which the same working fluid

undergoes a thermodynamic cycle to selectively supply the units **2**, **3** and **12**.

**[0114]** In other words, the plant comprises a closed circuit **D** in which flows a corresponding working fluid that undergoes a thermodynamic cycle and supplies, simultaneously or alternately, at least one unit **2** for conserving frozen or deep-frozen foods (or else an array of such units), and/or at least one unit **3** for conserving fresh foods (or a battery of such units), and/or at least one unit **12** for cooling the air in the room **I** (three units **12** are shown). The plant also comprises a circuit **C**, equivalent to the one described earlier in relation to figure **1**, intended for the circulation of hot water, and one or more thermal users **17**, **23**, **24**, **26** able to be selectively supplied with such water. Advantageously, the circuit **C** for circulating the hot water is subordinated, in cascade, to the circuit **D** for circulating the working fluid. In the exchanger **11**, the working fluid of the circuit **D** is placed in heat exchange relationship with the water flowing in the circuit **C**.

**[0115]** The operation of the plant shown in figure **2** is similar to that of the plant shown in figure **1**. The energy efficiency of the plant of figure **2** is lower than the efficiency of the plant of figure **1**, even if it may in any case be acceptable for some applications.

## Claims

1. Thermodynamic process for producing cold for refrigerating users (**2**, **3**, **12**) and for producing hot water for thermal users (**17**, **23**, **24**, **26**), comprising the steps of:

*aa*) implementing at least one thermodynamic cycle in which a working fluid flows in a closed circuit (**D**) and supplies at least one unit for conserving frozen or deep-frozen foods (**2**), and/or at least one unit for conserving fresh foods (**3**), and/or one or more units (**12**) for cooling the air in a room (**I**);

*bb*) providing one or more thermal users (**17**, **23**, **24**, **26**) to be selectively supplied with hot water,

**characterised in that** the hot water supplied to said thermal users (**17**, **23**, **24**, **26**) is in heat-exchange relationship with said working fluid and receives heat from the same.

2. Process according to claim 1, **characterised in that** there are two of the thermodynamic cycles in said step *aa*):

- a first thermodynamic cycle in which a first working fluid flows in a first closed circuit (**A**) and supplies at least one unit for conserving frozen or deep-frozen foods (**2**) and/or at least one unit for conserving fresh foods (**3**), and
- a second thermodynamic cycle in which a sec-

- ond working fluid flows in a second closed circuit (B) and during the hot seasons supplies one or more units (12) for cooling the air in a room (I), and **in that** the second working fluid is in heat exchange relationship with said first working fluid, and the hot water supplied to said thermal users (17, 23, 24, 26) is in heat exchange relationship with said second working fluid and receives heat from it, both during the hot seasons and during the cold seasons.
- 5
3. Process according to claim 2, **characterised in that** said first thermodynamic cycle and said second thermodynamic cycle are refrigerating cycles and **in that** said first working fluid transfers heat to said second working fluid.
- 10
4. Process according to any one of claims 1-3, **characterised in that** said hot water is collected in a tank (17) and directly or indirectly supplies one or more of said thermal users (17, 23, 24, 26).
- 15
5. Process according to any one of the previous claims 2-4, wherein, in a first operating mode, the step of making said first thermodynamic cycle in turn comprises the steps of:
- 20
- a) compressing said first working fluid;
- b) placing said first working fluid in heat exchange relationship with said second working fluid and transferring heat to said second working fluid in one or more heat exchangers (9);
- 25
- c) substantially completing the condensation of said first working fluid when necessary based upon the heat exchange conditions with said second working fluid;
- 30
- d) expanding and evaporating at least one part of said first working fluid at said at least one unit (2) for conserving frozen or deep-frozen foods and/or at at least one unit (3) for conserving fresh foods, and wherein
- 35
- The step of making said second thermodynamic cycle in turn comprises the steps of:
- 40
- e) compressing said second working fluid and placing it in heat exchange relationship with said hot water, transferring heat to it, and
- 45
- f) optionally, during the hot seasons, expanding and evaporating at least one part of said second working fluid at said at least one unit (12) for cooling the air in said room,
- 50
- and wherein in said step d) the first working fluid substantially absorbs the heat transferred during said steps b) and c) and in said step b) the second working fluid substantially absorbs the heat transferred during steps e) and f).
- 55
6. Process according to claim 5, wherein, in a second operating mode, during the cold seasons, said at least one unit (12) for cooling the air can be selectively deactivated and in said step b) the second working fluid substantially absorbs the heat transferred during step e).
7. Process according to any one of claims 2-6, wherein said thermal users (17, 23, 24, 26) are arranged in a third circuit and comprising at least one unit (23) for heating the air in a room (I), and/or at least one unit (24) for dehumidifying the air in a room (I), and/or one or more heating panels (26) arranged in the floor of said room (I) and a circuit (18) for distributing water for sanitary use.
8. Process according to claims 6 and 7, wherein, in a third operating mode during the hot seasons, said at least one unit (12) for cooling the air operates and said at least one unit (23) for heating the air in said room (I), said unit (24) for dehumidifying the air in the room (I) and said one or more radiator panels (26) can be selectively deactivated.
9. Process according to any one of claims 4-8, wherein said water for sanitary use is placed in heat exchange relationship with said hot water collected in said tank (17).
10. Process according to claim 5, wherein said step a) in turn comprises a step of compressing a first flow rate of said first working fluid suitable for ensuring the operation of said at least one unit (2) for conserving frozen or deep-frozen foods, and a step of compressing a second flow rate of said first working fluid suitable for ensuring the operation of said at least one unit (3) for conserving fresh foods.
11. Thermal plant (1), comprising:
- at least one closed circuit (D) in which flows a corresponding working fluid that undergoes a thermodynamic cycle and supplies at least one unit (2) for conserving frozen or deep-frozen foods, and/or at least one unit (3) for conserving fresh foods, and/or at least one unit (12) for cooling the air in a room (I), and
  - a closed circuit (C) for circulating hot water and one or more thermal users (17, 23, 24, 26) that can be selectively supplied with said hot water,
- characterised in that** said circuit (C) for circulating the hot water is subordinated in cascade to said circuit (D) for circulating said working fluid.
12. Thermal plant (1) according to claim 11, **characterised in that** it comprises:
- a first closed circuit (A) in which flows a first working fluid that undergoes a first thermody-

- dynamic cycle and supplies at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods, and - a second closed circuit (B), separate from said first circuit (A), in which flows as second working fluid that undergoes a second thermodynamic cycle and, during the hot seasons, supplies at least one unit (12) for cooling the air in a room (I), and **in that** said first (A), second (B) and third (C) circuit are arranged in cascade, with said third circuit (C) being subordinated to said second circuit (B) and said second circuit (B) being subordinated to said first circuit (A).
13. Thermal plant (1) according to claim 11 or claim 12, wherein said at least one unit (2) for conserving frozen or deep-frozen foods is a counter, cabinet or cold room at a temperature of between about -25°C and about -14°C.
14. Thermal plant (1) according to claim 11 or claim 12, wherein said at least one unit (3) for conserving fresh foods is a counter, cabinet or cold room at a temperature of between about -1°C and about +10°C.
15. Thermal plant (1) according to any one of the previous claims 12-14, wherein said first working fluid at least partially evaporates, absorbing heat, at said at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods.
16. Thermal plant (1) according to any one of the previous claims 12-15, wherein said second working fluid is in heat exchange relationship with said first working fluid at a heat exchanger (9) shared between said first circuit (A) and said second circuit (B).
17. Thermal plant (1) according to any one of the previous claims 11-16, comprising means (211, 311, 14) for selectively deactivating one or more units (2) for conserving fresh foods, and/or one or more units (3) for conserving frozen or deep-frozen foods, and/or one or more units (12) for cooling the air in said room (I).
18. Thermal plant (1) according to claim 17, when dependent upon any one of claims 12-16, wherein said selective deactivation means comprise at least one valve (211, 311, 14) for intercepting a portion of said first circuit (A) or said second circuit (B) and a corresponding by-pass circuit of the relative working fluid.
19. Thermal plant (1) according to any one of the previous claims 12-18, comprising a heat exchange device (7) at which said first working fluid is in heat exchange relationship with the outside (E) of said room (I), said heat exchange device (7) comprising a condensing portion, at which said first working fluid transfers heat to the air outside (E) based upon the heat exchange conditions made upstream with said second working fluid.
20. Thermal plant (1) according to any one of the previous claims 12-19, wherein:
- said second circuit (B) comprises at least one compressor (10) for the circulation of said second working fluid, said compressor (10) having a refrigerating capacity suitable for ensuring the operation of said at least one unit (12) for cooling the air, and
  - said first circuit (A) comprises a plurality of compressors (4) for the circulation of said first working fluid, a first group (4a) of compressors having a refrigerating capacity suitable for ensuring the operation of said at least one unit (2) for conserving frozen or deep-frozen foods, and a second group (4b) of compressors having a refrigerating capacity suitable for ensuring the operation of said at least one unit (3) for conserving fresh foods.
21. Thermal plant (1) according to any one of the previous claims 12-20, comprising expansion means (212, 312) of said first working fluid and expansion means (15) of said second working fluid, selected from thermal expansion valves and capillaries, or else flooding supply systems of the evaporating portions of said unit (2) for conserving frozen or deep-frozen foods, and said unit (3) for conserving fresh foods.
22. Thermal plant (1) according to any one of the previous claims 12-21, wherein said first working fluid and second working fluid are refrigeration fluids selected from the group comprising hydrofluorocarbons (HFC), hydrochlorofluorocarbons (HCFC), carbon dioxide, propane, ammonia.
23. Thermal plant (1) according to claim 22, wherein said refrigeration fluid is a hydrofluorocarbon (HFC) selected from the group comprising R-507A and R-404A.
24. Thermal plant (1) according to any one of the previous claims 12-23, wherein said third circuit (C) comprises:
- at least one first heat exchanger (11), shared with said second circuit (B), in which said water flow rate receives heat from said second working fluid,
  - at least one tank (17) for collecting water, supplied with said water flow rate, heated to a tem-

perature of over 35°C, arriving from said first heat exchanger (11), and wherein

- said one or more thermal users are supplied directly with hot water taken from said tank (17), or else are supplied with a corresponding working fluid placed in heat exchange relationship with said hot water in said tank (17).

25. Thermal plant (1) according to any one of the previous claims 11-24, wherein said one or more thermal users are selected from a unit (23) for heating the air in said room (I), a unit (24) for dehumidifying the air in said room (I), one or more heating panels (26) arranged in a floor in said room (I) and a circuit (18) for distributing water for sanitary use.

26. Thermal plant (1) according to claim 25, comprising a microprocessor control unit suitable for controlling the operation of said thermal plant in feedback based upon the required operating conditions at:

- said at least one unit (12) for cooling the air in said room (I), and  
 - said at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods, and  
 - said at least one unit (23) for heating the air in said room (I) or said at least one unit (24) for dehumidifying the air in said room (I) or said one or more radiator panels (26), and  
 - said circuit for distributing water for sanitary use (18).

27. Thermal plant (1) according to any one of the previous claims 11-26, wherein said room (I) is a shop at least in part intended for selling food, or a dining establishment.

#### Amended claims in accordance with Rule 137(2) EPC.

1. Thermodynamic process for producing cold for refrigerating users (2, 3, 12) and for producing hot water for thermal users (17, 23, 24, 26), comprising the steps of:

*aa*) implementing at least one thermodynamic cycle in which a working fluid flows in a closed circuit (D) and supplies at least one unit for conserving frozen or deep-frozen foods (2), and/or at least one unit for conserving fresh foods (3), and/or one or more units (12) for cooling the air in a room (I);  
*bb*) providing one or more thermal users (17, 23, 24, 26) to be selectively supplied with hot water,

wherein the hot water supplied to said thermal users

(17, 23, 24, 26) is in heat-exchange relationship with said working fluid and receives heat from the same, and wherein there are two of the thermodynamic cycles in said step *aa*):

- a first thermodynamic cycle in which a first working fluid flows in a first closed circuit (A) and supplies at least one unit for conserving frozen or deep-frozen foods (2) and/or at least one unit for conserving fresh foods (3), and  
 - a second thermodynamic cycle in which a second working fluid flows in a second closed circuit (B) and during the cooling demand supplies one or more units (12) for cooling the air in a room (I),

and wherein the second working fluid is in heat exchange relationship with said first working fluid, and the hot water supplied to said thermal users (17, 23, 24, 26) is in heat exchange relationship with said second working fluid and receives heat from it, both during the cooling demand and during the heating demand, and wherein said first thermodynamic cycle and said second thermodynamic cycle are refrigerating cycles and in that said first working fluid transfers heat to said second working fluid.

2. Process according to claim 1, **characterised in that** said hot water is collected in a tank (17) and directly or indirectly supplies one or more of said thermal users (17, 23, 24, 26).

3. Process according to any one of the previous claims 1-2, wherein, in a first operating mode, the step of making said first thermodynamic cycle in turn comprises the steps of:

*a*) compressing said first working fluid;  
*b*) placing said first working fluid in heat exchange relationship with said second working fluid and transferring heat to said second working fluid in one or more heat exchangers (9);  
*c*) substantially completing the condensation of said first working fluid when necessary based upon the heat exchange conditions with said second working fluid;  
*d*) expanding and evaporating at least one part of said first working fluid at said at least one unit (2) for conserving frozen or deep-frozen foods and/or at at least one unit (3) for conserving fresh foods, and wherein the step of making said second thermodynamic cycle in turn comprises the steps of:  
*e*) compressing said second working fluid and placing it in heat exchange relationship with said hot water, transferring heat to it, and  
*f*) optionally, during the cooling demand, expanding and evaporating at least one part of said second working fluid at said at least one unit (12)

for cooling the air in said room,

and wherein in said step *d*) the first working fluid substantially absorbs the heat transferred during said steps *b*) and *c*) and in said step *b*) the second working fluid substantially absorbs the heat transferred during steps *e*) and *f*).

**4.** Process according to claim 3, wherein, in a second operating mode, during the heating demand, said at least one unit (12) for cooling the air can be selectively deactivated and in said step *b*) the second working fluid substantially absorbs the heat transferred during step *e*).

**5.** Process according to any one of claims 1-4, wherein said thermal users (17, 23, 24, 26) are arranged in a third circuit and comprising at least one unit (23) for heating the air in a room (I), and/or at least one unit. (24) for dehumidifying the air in a room (I), and/or one or more heating panels (26) arranged in the floor of said room (I) and a circuit (18) for distributing water for sanitary use.

**6.** Process according to claims 4 and 5, wherein, in a third operating mode during the cooling demand, said at least one unit (12) for cooling the air operates and said at least one unit (23) for heating the air in said room (I), said unit (24) for dehumidifying the air in the room (I) and said one or more radiator panels (26) can be selectively deactivated.

**7.** Process according to any one of claims 2-6, wherein said water for sanitary use is placed in heat exchange relationship with said hot water collected in said tank (17).

**8.** Process according to claim 3, wherein said step *a*) in turn comprises a step of compressing a first flow rate of said first working fluid suitable for ensuring the operation of said at least one unit (2) for conserving frozen or deep-frozen foods, and a step of compressing a second flow rate of said first working fluid suitable for ensuring the operation of said at least one unit (3) for conserving fresh foods.

**9.** Thermal plant (1), comprising:

- at least one closed circuit (D) in which flows a corresponding working fluid that undergoes a thermodynamic cycle and supplies at least one unit (2) for conserving frozen or deep-frozen foods, and/or at least one unit (3) for conserving fresh foods, and/or at least one unit (12) for cooling the air in a room (I), and
- a closed circuit (C) for circulating hot water and one or more thermal users (17, 23, 24, 26) that can be selectively supplied with said hot water,

wherein said circuit (C) for circulating the hot water is subordinated in cascade to said circuit (D) for circulating said working fluid, and wherein it further comprises:

- a first closed circuit (A) in which flows a first working fluid that undergoes a first thermodynamic cycle and supplies at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods, and
- a second closed circuit (B), separate from said first circuit (A), in which flows as second working fluid that undergoes a second thermodynamic cycle and, during the hot seasons, supplies at least one unit (12) for cooling the air in a room (I),

and wherein said first (A), second (B) and third (C) circuit are arranged in cascade, with said third circuit (C) being subordinated to said second circuit (B) and said second circuit (B) being subordinated to said first circuit (A).

**10.** Thermal plant (1) according to claim 9, wherein said at least one unit (2) for conserving frozen or deep-frozen foods is a counter, cabinet or cold room at a temperature of between about -25°C and about -14°C.

**11.** Thermal plant (1) according to claim 9 or claim 10, wherein said at least one unit (3) for conserving fresh foods is a counter, cabinet or cold room at a temperature of between about -1°C and about +10°C.

**12.** Thermal plant (1) according to any one of the previous claims 9-11, wherein said first working fluid at least partially evaporates, absorbing heat, at said at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods.

**13.** Thermal plant (1) according to any one of the previous claims 9-12, wherein said second working fluid is in heat exchange relationship with said first working fluid at a heat exchanger (9) shared between said first circuit (A) and said second circuit (B).

**14.** Thermal plant (1) according to any one of the previous claims 9-13, comprising means (211, 311, 14) for selectively deactivating one or more units (2) for conserving fresh foods, and/or one or more units (3) for conserving frozen or deep-frozen foods, and/or one or more units (12) for cooling the air in said room (I).

**15.** Thermal plant (1) according to claim 14, wherein said selective deactivation means comprise at least one valve (211, 311, 14) for intercepting a portion of said first circuit (A) or said second circuit (B) and a

corresponding by-pass circuit of the relative working fluid.

**16.** Thermal plant (1) according to any one of the previous claims 9-15, comprising a heat exchange device (7) at which said first working fluid is in heat exchange relationship with the outside (E) of said room (I), said heat exchange device (7) comprising a condensing portion, at which said first working fluid transfers heat to the air outside (E) based upon the heat exchange conditions made upstream with said second working fluid.

**17.** Thermal plant (1) according to any one of the previous claims 9-16, wherein:

- said second circuit (B) comprises at least one compressor (10) for the circulation of said second working fluid, said compressor (10) having a refrigerating capacity suitable for ensuring the operation of said at least one unit (12) for cooling the air, and
- said first circuit (A) comprises a plurality of compressors (4) for the circulation of said first working fluid, a first group (4a) of compressors having a refrigerating capacity suitable for ensuring the operation of said at least one unit (2) for conserving frozen or deep-frozen foods, and a second group (4b) of compressors having a refrigerating capacity suitable for ensuring the operation of said at least one unit (3) for conserving fresh foods.

**18.** Thermal plant (1) according to any one of the previous claims 9-17, comprising expansion means (212, 312) of said first working fluid and expansion means (15) of said second working fluid, selected from thermal expansion valves and capillaries, or else flooding supply systems of the evaporating portions of said unit (2) for conserving frozen or deep-frozen foods, and said unit (3) for conserving fresh foods.

**19.** Thermal plant (1) according to any one of the previous claims 9-18, wherein said first working fluid and second working fluid are refrigeration fluids selected from the group comprising hydrofluorocarbons (HFC), hydrochlorofluorocarbons (HCFC), carbon dioxide, propane, ammonia.

**20.** Thermal plant (1) according to claim 19, wherein said refrigeration fluid is a hydrofluorocarbon (HFC) selected from the group comprising R-507A and R-404A.

**21.** Thermal plant (1) according to any one of the previous claims 9-20, wherein said third circuit (C) comprises:

- at least one first heat exchanger (11), shared with said second circuit (B), in which said water flow rate receives heat from said second working fluid,
- at least one tank (17) for collecting water, supplied with said water flow rate, heated to a temperature of over 35°C, arriving from said first heat exchanger (11), and wherein
- said one or more thermal users are supplied directly with hot water taken from said tank (17), or else are supplied with a corresponding working fluid placed in heat exchange relationship with said hot water in said tank (17).

**22.** Thermal plant (1) according to any one of the previous claims 9-21, wherein said one or more thermal users are selected from a unit (23) for heating the air in said room (I), a unit (24) for dehumidifying the air in said room (I), one or more heating panels (26) arranged in a floor in said room (I) and a circuit (18) for distributing water for sanitary use.

**23.** Thermal plant (1) according to claim 22, comprising a microprocessor control unit suitable for controlling the operation of said thermal plant in feedback based upon the required operating conditions at:

- said at least one unit (12) for cooling the air in said room (I), and
- said at least one from a unit (2) for conserving frozen or deep-frozen foods and a unit (3) for conserving fresh foods, and
- said at least one unit (23) for heating the air in said room (I) or said at least one unit (24) for dehumidifying the air in said room (I) or said one or more radiator panels (26), and
- said circuit for distributing water for sanitary use (18).

**24.** Thermal plant (1) according to any one of the previous claims 9-23, wherein said room (I) is a shop at least in part intended for selling food, or a dining establishment.

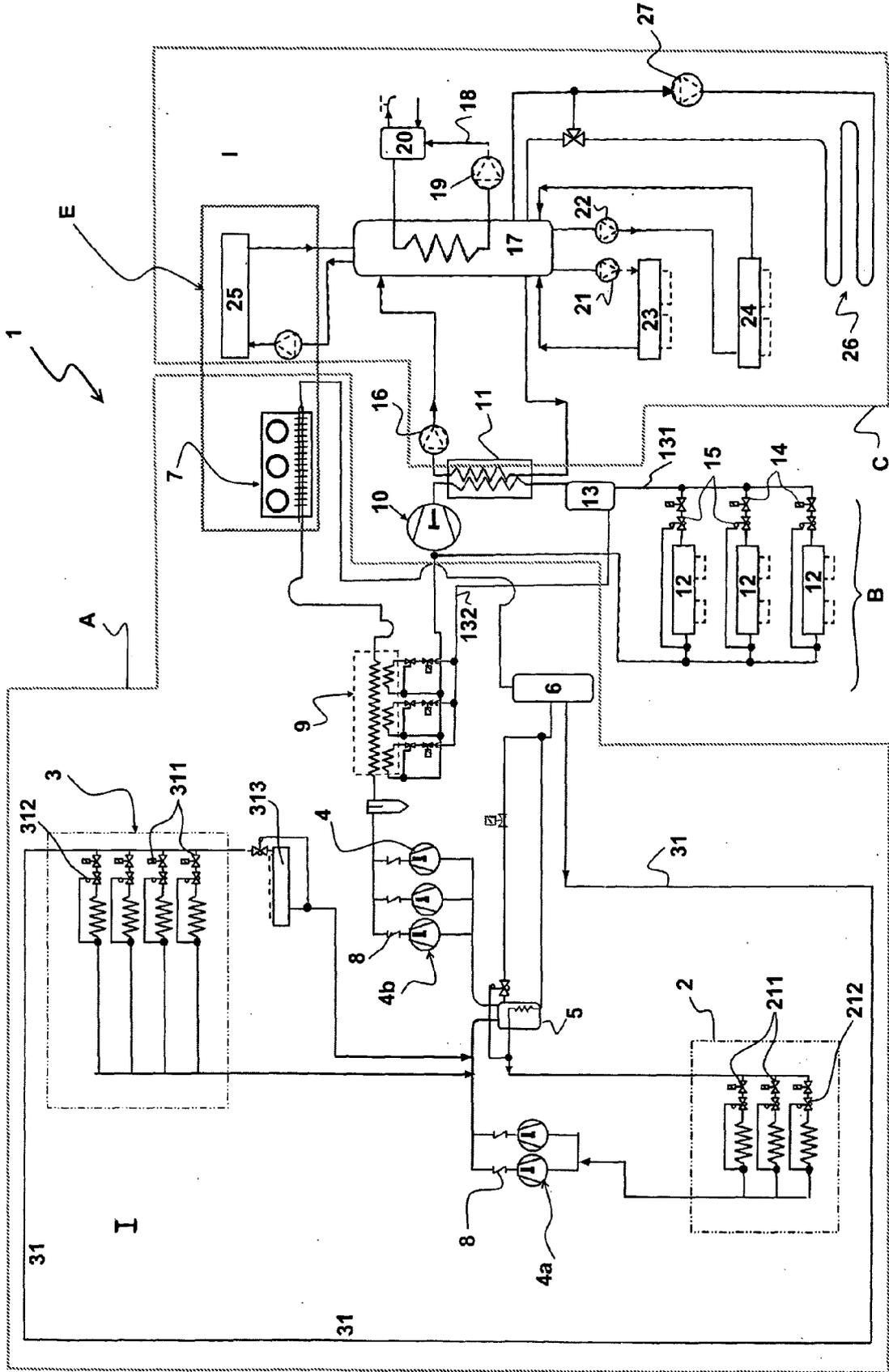
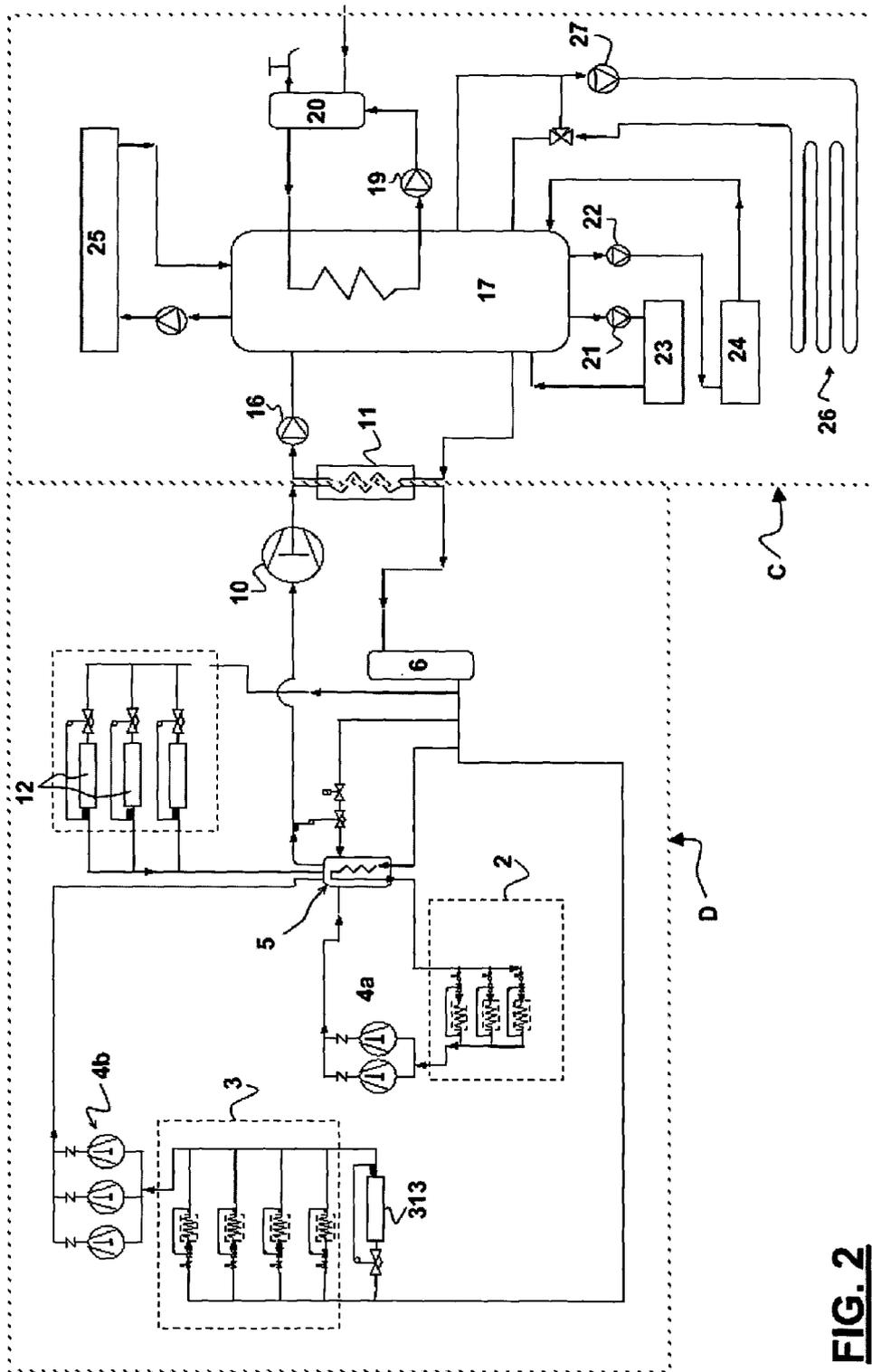


FIG. 1



**FIG. 2**



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<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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