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(54) Installation and process for producing cold and adjusting air temperature, and thermal exchange device usable in such an installation

(57) The invention refers to a thermal installation (1) comprising a closed circuit (2), wherein a working fluid carries out a thermodynamic cycle, comprising a plurality of thermal user points (5), at which said working fluid is at a temperature suitable for the heat exchange with at least one unit (9) for adjusting air temperature of an environment (A) and at least one of a deep-frozen or frozen food conservation unit (7) and a fresh food conservation unit (8).

The invention also refers to a heat exchange device (4) that can be used in the aforementioned thermal installation (1) and to a thermodynamic process for producing cold and adjusting air temperature of environment (A) that can be actuated through such an installation.

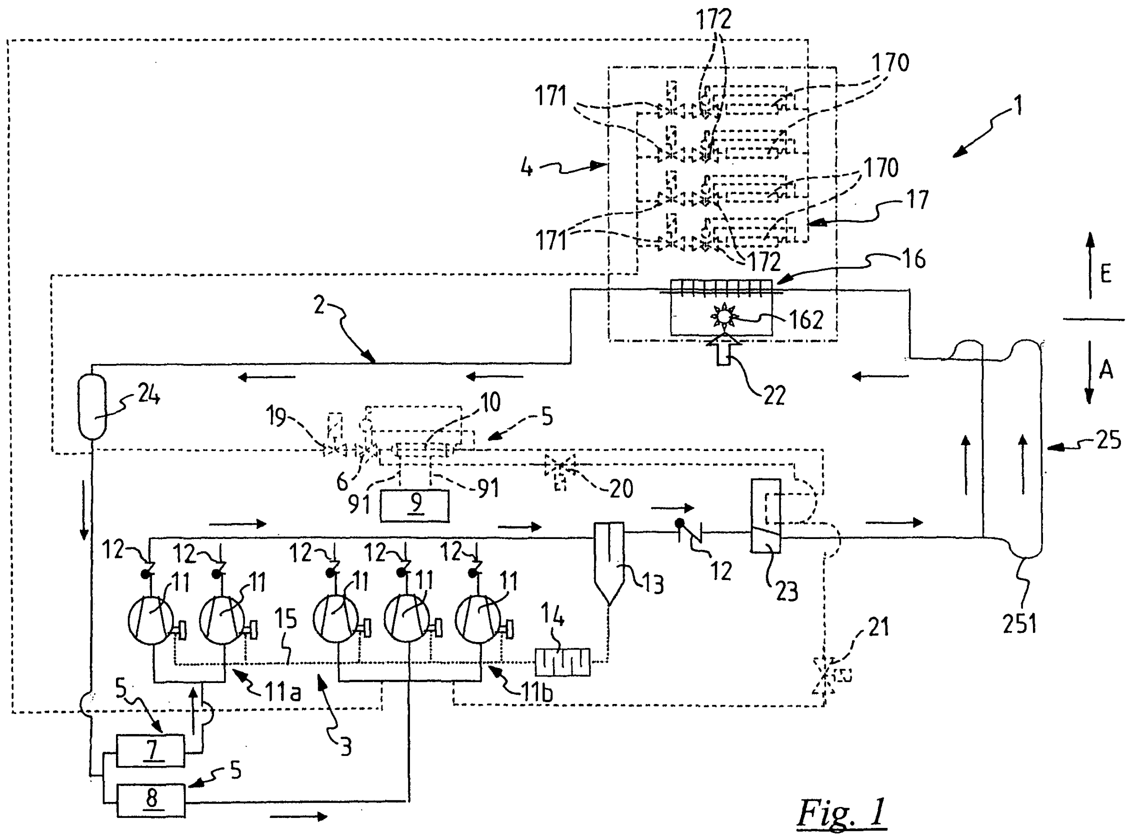

Fig. 1

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Description

[0001] The present invention refers to a thermal installation for producing cold and adjusting air temperature of an environment, which has preferred, although not exclusive, use in environments where it is necessary to conserve deep frozen or frozen and/or fresh food.

[0002] The invention also refers to a thermal exchange device usable in the aforementioned thermal installation, and to a process for producing cold and for adjusting air temperature of an environment that can be carried out through such an installation.

[0003] In many applications, for example commercial concerns such as mini or supermarkets, food sellers and the like, and dining points such as canteens, restaurants, snack bars and the like, there is a first requirement to provide for units for conserving food at a controlled temperature, typically lower than that of the environments where such units are set. The food can be fresh food, for example meat, fruit, vegetables, dairy products, soft drinks, desserts or gastronomic products etc., and deep-frozen or frozen food. The conservation at a controlled temperature can, for example, be intended for the display and sale of food or for storage thereof.

[0004] For the conservation of food, refrigerated counters or cabinets having various shapes and sizes, or else cold-storage rooms of various sizes are commonly used.

[0005] The operation of such units is usually ensured by suitable installations for producing cold, associated with each unit or else centralised and provided for serving a plurality of units.

[0006] In the above-mentioned applications there is at the same time a second requirement, which is that of adjusting air temperature of the environment so as to make it comfortable for employees and customers or patrons to be in, both during the cold seasons and during the hot seasons. In order to meet such a requirement, suitable air-conditioning installations and/or heat pump installations are commonly used, that comprise one or more units suitable for adjusting air temperature through thermal exchange with a working fluid of such installations. Such units can, for example, be "fan-coil" units or the like.

[0007] In certain cases, the possibility of setting up installations for producing cold and installations for adjusting air temperature can be restricted due to the low space available and/or due to building constraints. This can occur, for example, in the case of old buildings of historical town centres.

[0008] The object of the present invention is to provide a thermal installation that allows the aforementioned requirements to be simultaneously met in an effective way and with the least possible number of components, so as to reduce the overall size and the extent of the interventions necessary to set up the installation.

[0009] According to a first aspect thereof, the invention refers to a thermal installation comprising a closed circuit wherein a working fluid carries out a thermodynamic cycle, said closed circuit comprising a plurality of thermal user points, at which said working fluid is at a temperature suitable for thermal exchange with at least one unit for adjusting air temperature of an environment and at least one of a deep-frozen or frozen food conservation unit and a fresh food conservation unit.

[0010] Within the present description and the subsequent claims, the term "environment" is used to generally indicate a limited portion of space and the term "outside" is used to generally indicate any space outside said environment, although possibly located indoors. More specifically, environment is used to indicate the commercial concern or the dining point where the installation is set up, irrespective of whether it comprises just one or many rooms.

[0011] The thermal installation of the invention advantageously allows the requirements of producing cold and of adjusting air temperature to be satisfied by sharing the closed circuit and many components, with a substantially reduced number of components with respect to those required by separate installations for producing cold and for adjusting air temperature. Thus both the overall size of the installation, and the interventions required for setting up the installation are reduced. This is particularly advantageous in the case of small environments and/or environments located in old buildings, where the possibility of carrying out structural interventions for setting up installations can be limited. Moreover, as shall also become clearer from the following description, the use of a single installation for producing cold and for adjusting air temperature advantageously allows achieving a greater operating flexibility of the units intended to carry out such functions.

[0012] Typically, the at least one deep-frozen or frozen food conservation unit is a counter, cabinet or cold-storage room at a temperature between about -14°C and about -25°C. In particular, such a temperature is preferably between about -14°C and about -16°C in the case of conservation of frozen food, is preferably equal to or less than about - 18°C in the case of conservation of deep-frozen food and is preferably close to about -25°C in the case of conservation of industrial ice cream.

[0013] Typically, the at least one fresh food conservation unit is a counter, cabinet or cold-storage room at a temperature between about +10°C and about -1°C. In particular, such a temperature is preferably between about +8°C and about +6°C in the case of conservation of fruit and vegetables, is preferably between about +5°C and about +3°C in the case of conservation of dairy products and cold pork and salami and is preferably between about +2°C and about 0°C in the case of conservation of meat and poultry.

[0014] Preferably, the aforementioned environment is a commercial concern at least partially intended for the sale of food or a dining point.

[0015] In a preferred embodiment, the at least one of the deep-frozen or frozen food conservation unit and the fresh food conservation unit directly operate with the working fluid flowing in the closed circuit, and is hydraulically connected with the closed circuit of the thermal installation at the respective thermal user point. In this case the production of cold at such units takes place by direct expansion of the working fluid, with advantages for the simplification of the installation and the efficiency of the aforementioned units.

[0016] In alternative embodiments it is however possible for the at least one deep-frozen or frozen food conservation unit and/or the at least one fresh food conservation unit to operate with a thermal carrier fluid, preferably an unfreezable thermal carrier fluid, distinct from the working fluid and in thermal exchange relationship with it. In this case, such units are connected with one or more secondary circuits hydraulically separate from the closed circuit of the thermal installation and in thermal exchange relationship with it at one or more thermal exchange elements in said thermal user points.

[0017] Also for the unit for adjusting air temperature embodiments may be foreseen in which such a unit operates directly with the working fluid. However, it is preferred that this unit operates with its own thermal carrier fluid, for example water, distinct from the working fluid and in thermal exchange relationship with it. The at least one unit for adjusting air temperature is therefore preferably connected with a secondary circuit hydraulically separate from the closed circuit of the thermal installation and in thermal exchange relationship with it at one or more thermal exchange elements in a thermal user point.

[0018] In this preferred embodiment, the thermal carrier fluid flowing in the unit for adjusting air temperature can advantageously be kept at a positive temperature even when the unit is active to cool the environment. This substantially avoids the formation, at the thermal exchange bank of such a unit, of frost that, being thermally insulating, would hinder the thermal exchange with the air of the environment. Moreover, a more comfortable climate is achieved, since the temperature difference of the air emitted by the unit with respect to the temperature of the environment can be better controlled, therefore reducing the risk of people suffering from thermal shocks.

[0019] Preferably, the thermal installation of the invention comprises means for switching between an operating mode wherein the at least one unit for adjusting air temperature cools the environment and an operating mode wherein the at least one unit for adjusting air temperature heats the environment. The thermal installation of the invention can therefore be used for adjusting air temperature both during hot seasons and during cold seasons, substantially without jeopardising the operation of the at least one deep-frozen or frozen food conservation unit and/or of the at least one fresh food conservation unit.

[0020] Preferably, the means for switching comprise a reversing cycle valve and means for intercepting portions of the closed circuit.

[0021] In a preferred embodiment, the thermal installation of the invention comprises a thermal exchange device at which the working fluid is in thermal exchange relationship with the outside of the environment, and said thermal exchange device comprises a condensing portion, at which the working fluid releases heat, and an evaporating portion, at which the working fluid can at least partially, and preferably substantially, absorb the heat released at the condensing portion.

[0022] The thermal exchange between condensing portion and evaporating portion allows the operation of the thermal installation to be improved, in particular during the cold seasons, when the at least one unit for adjusting air temperature is typically active to heat the environment.

[0023] Indeed, the condensing portion per se has a substantially analogous function to that of a condenser in a conventional refrigerating installation and allows the heat absorbed by the working fluid at the at least one deep-frozen or frozen food conservation unit, and/or at the at least one fresh food conservation unit and at the at least one unit for adjusting air temperature, when it is active to cool the environment, to be released to the outside of said environment. The evaporating portion *per* se has a substantially analogous function to that of an evaporator in a conventional heat pump installation and allows the working fluid to absorb heat from the outside of the environment and to release it at the at least one unit for adjusting air temperature, when it is active to heat such an environment.

[0024] In the aforementioned heat exchange device, the heat released by the condensing portion, which would otherwise be lost, is at least partially and preferably substantially used to heat the evaporating portion. Thanks to such heating, the evaporating portion can exchange heat also at lower outside temperatures with respect to those at which a conventional heat pump installation could operate. Such temperatures have indeed a lower limit determined by the formation, at the evaporator, of frost, which, being thermally insulating, hinders the heat exchange.

[0025] In this way, with the thermal installation of the invention it is possible to obtain a wider working range of the at least one unit for adjusting air temperature, when it is active for heating, without influencing the operation of the at least one deep-frozen or frozen food conservation unit and/or of the at least one fresh food conservation unit.

[0026] Preferably, the condensing portion comprises at least one first fluid path and the evaporating portion comprises at least one second fluid path and these fluid paths comprise a plurality of ducts embedded in a same assembly of fins. The heat exchange between condensing portion and evaporating portion can therefore advantageously take place both by convection of a fluid, preferably air, externally flowing in contact with the ducts, and by conduction through the fins.

[0027] The fluid paths of the condensing and evaporating portions of the heat exchange device are preferably coil-shaped.

[0028] The aforementioned thermal exchange device preferably further comprises means for forcedly circulating said fluid externally of the fluid paths of the condensing and evaporating portions of the thermal exchange device. This allows the efficiency of the convective thermal exchange to be increased and a preferential flow direction of the fluid through the device to be ensured, so that it firstly flows in contact with the condensing portion, heating up, and then in contact with the evaporating portion. The aforementioned means for the forced circulation are of conventional type and can comprise, for example, one or more fans, typically electrically actuated.

[0029] Preferably, the evaporating portion of the thermal exchange device comprises a plurality of second fluid paths connected in parallel and selectively interceptable through a corresponding plurality of interception means.

[0030] Through the opening or closing of one or more of said interception means it is possible to include or exclude one or more fluid paths of the evaporating portion into/from the closed circuit of the thermal installation, thus changing the overall thermal exchange surface of the evaporating portion and therefore, the other conditions being the same, the amount of heat exchanged by the working fluid at the evaporating portion.

[0031] The condensing portion also preferably comprises a plurality of first fluid paths connected in parallel. However, in the case of the condensing portion it is preferred not to use interception means to intercept such fluid paths. The thermal exchange at the condensing portion is preferably controlled by changing the flow rate of the fluid externally flowing in contact with such a portion, for example through the means for the forced circulation described above.

[0032] In a preferred embodiment, the thermal installation of the invention comprises a plurality of compressors defining a compression section of the working fluid, wherein a first group of compressors of said plurality of compressors has a refrigerating capacity suitable for ensuring the operation of said at least one deep-frozen or frozen food conservation unit and a second group of compressors of said plurality of compressors has a refrigerating capacity suitable for ensuring the operation of said at least one fresh food conservation unit and of said at least one unit for adjusting air temperature.

[0033] The operation of the at least one deep-frozen or frozen food conservation unit is thus ensured by a group of compressors exclusively dedicated to such a unit. It can thus be controlled, and, possibly, excluded from the closed circuit of the thermal installation, without substantially influencing the performance of the at least one fresh food conservation unit and of the at least one unit for adjusting air temperature. The operation of these units, on the other hand, is ensured by the same group of compressors. This allows, in the case of failure of one of the compressors in the group, the operation of the at least one fresh food conservation unit to be ensured, at least to a limited extent, partially limiting or totally excluding the air temperature adjustment function.

[0034] In any case, the number of compressors present in the compression section and their allotment to the aforementioned two groups are preferably selected based on the number and type of units an on the type of environment for which the thermal installation is intended.

[0035] The thermal installation of the invention comprises expansion means for expanding the working fluid preferably selected from thermostatic valves and capillaries.

[0036] In alternative embodiments, in particular for high power installations, as an alternative or in addition to the use of the aforementioned expansion means, it is possible to carry out the expansion of the working fluid through flooding evaporators with "float" valves.

[0037] Preferably, the thermal installation comprises means for the separation and recovery of a lubricating fluid, typically oil coming from the compressors, dispersed in said working fluid.

[0038] Preferably, the working fluid is a refrigerating fluid selected from the group comprising hydro-fluoro-carbons (HFC), hydro-chloro-fluoro-carbons (HCFC), carbon dioxide, propane and ammonia.

[0039] More preferably, said refrigerating fluid is one of the hydro-fluoro-carbons (HFC) known under the ASHRAE denomination R-507A or R-404A.

[0040] In a preferred embodiment, the thermal installation of the invention comprises a microprocessor control unit adapted to control the operation of the thermal installation according to the required thermal conditions at the at least one unit for adjusting air temperature and the at least one of the deep-frozen or frozen food conservation unit and the fresh food conservation unit.

[0041] In a preferred embodiment, each of the component elements of the thermal installation of the invention has a plan overall size not greater than 80 cm by 120 cm. Such size is that of standard pallets typically used for the transportation of foodstuffs. Therefore it is advantageously ensured that the installation in disassembled condition can be easily introduced in any environment adapted to the entry of such pallets without the need for special provisions.

[0042] According to a second aspect thereof, the present invention refers to a heat exchange device comprising a condensing portion, at which a working fluid releases heat, and an evaporating portion, at which said working fluid can at least partially, and preferably substantially, absorb the heat released at the condensing portion, wherein said condensing portion comprises at least one first fluid path and said evaporating portion comprises at least one second fluid path, said at least one first and at least one second fluid paths being embedded in the same assembly of fins.

[0043] Such a heat exchange device allows specific advantages to be achieved when used in the thermal installation of the present invention, as described above, but it can also have advantageous uses in other types of installation, and generally in all cases where one wishes to lower the minimum temperature at which it is possible to operate a heat pump.

[0044] According to a third aspect thereof, the present invention refers to a thermodynamic process comprising the step of carrying out a thermodynamic cycle wherein a working fluid reaches, at a plurality of thermal user points, a plurality of temperatures suitable for the operation of at least one unit for adjusting air temperature of an environment and at least one of a deep-frozen or frozen food conservation unit and a fresh food conservation unit.

[0045] Preferably, in the process of the invention, in a first operating mode, the operation of the at least one unit for adjusting air temperature is selectively deactivatable.

[0046] Preferably, in the process of the invention, in a second operating mode, the operation of the at least one unit for adjusting air temperature is for cooling the air temperature.

[0047] Preferably, in the process of the invention, in a third operating mode, the operation of the at least one unit for adjusting air temperature is for heating the air temperature.

[0048] Preferably, in said third operating mode, said step of carrying out a thermodynamic cycle comprises the steps of:

a) compressing the working fluid;
b) placing the working fluid in thermal exchange relationship with the at least one unit for adjusting air temperature, determining at least partially the condensation thereof;
c) substantially completing the condensation of the working fluid;
d) expanding and evaporating at least part of the working fluid,

wherein in said step d) the working fluid at least partially and preferably substantially absorbs the heat released during said step c).

[0049] Preferably, in said third operating mode, the step of carrying out a thermodynamic cycle comprises the step of causing a forced flow of a fluid, preferably air, to promote the absorption in said step d) of the heat released in said step c).

[0050] Preferably, said step of carrying out a thermodynamic cycle comprises a step of compressing a first flow rate of said working fluid, suitable for ensuring the operation of the at least one deep-frozen or frozen food conservation unit, and a step of compressing a second flow rate of said working fluid, suitable for ensuring the operation of the at least one fresh food conservation unit and of the at least one unit for adjusting air temperature.

[0051] Preferably, the operation of the at least one unit for adjusting air temperature is subordinated to the correct operation of the at least one fresh food conservation unit.

[0052] 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 drawings, wherein:

- figure 1 is a block diagram of a thermal installation according to a preferred embodiment of the invention, in a first operating mode;
- figure 2 is a block diagram of the thermal installation of figure 1, in a second operating mode;
- figure 3 is a block diagram of the thermal installation of figure 1, in a third operating mode;
- figure 4 is a schematic view of a thermal exchange device according to the invention, that can be used in the thermal installation of figure 1.

[0053] In figures 1-3 a thermal installation for producing cold and adjusting air temperature in accordance with the invention is globally indicated with reference numeral 1. The thermal installation 1 essentially comprises a closed circuit 2 for circulating a working fluid, comprising: a compression section 3 of the working fluid, a thermal exchange device 4, at which the working fluid is in thermal exchange relationship with the outside E of an environment A, means 6 and 172 for expanding the working fluid and a plurality of thermal user points 5.

[0054] The working fluid is a refrigerating fluid, for example one of the hydro-fluoro-carbons (HFC) known under the ASHRAE denomination R-507A or R-404A.

[0055] The thermal installation 1 is preferably employed in an environment A where it is necessary to conserve fresh and/or deep frozen/frozen food, for example for sale purposes, in retail or wholesale, or for dining purposes. Such applications comprise commercial concerns such as mini or supermarkets, food sellers and the like, and dining points such as canteens, restaurants, snack bars and the like.

[0056] According to the invention, at the thermal user points 5 the working fluid is at a temperature suitable for being placed in thermal exchange relationship with a deep-frozen or frozen food conservation unit 7, with a fresh food conservation unit 8, and with a unit 9 for adjusting air temperature of environment A or of one or more rooms thereof.

[0057] The units 7 and 8 can, for example, be refrigerated counter or cabinets or cold-storage rooms. The unit 9 can be, for example, a "fan coil" type unit.

[0058] The deep-frozen or frozen food conservation unit 7 and the fresh food conservation unit 8 are preferably hydraulically connected with the closed circuit 2 and operate through direct expansion of the working fluid. Such units 7, 8 are preferably arranged on separate lines of the closed circuit 2, so that a failure or a maintenance intervention on one line does not at the same time jeopardise the operation of both units 7, 8.

[0059] The unit 9 for adjusting air temperature is instead preferably connected with a secondary circuit 91 hydraulically separate from the closed circuit 2, wherein a thermal carrier fluid, for example water, distinct from the working fluid of the closed circuit 2, is circulated. The working fluid and the thermal carrier fluid are placed in thermal exchange relationship at a heat exchanger 10, preferably a countercurrent heat exchanger, shared by the closed circuit 2 and the secondary circuit 91.

[0060] In the embodiment illustrated here there are three thermal user points 5, but it is clear that their number can vary according to the specific requirements and, in particular, can be greater if there are more deep-frozen or frozen food conservation units 7 or more fresh food conservation units 8. As far as the adjustment of the air temperature is concerned, more units 9 can be provided, preferably connected with the same or with more secondary circuits 91, or else directly in respective thermal user points 5 of the closed circuit 2.

[0061] This could involve a different sizing of the thermal installation 1 in terms of number and/or size of other component elements of the installation, without for this reason departing from the scope of the invention.

[0062] Since the temperature at the deep-frozen or frozen food conservation unit 7 is typically between about -14°C and about -25°C - in particular, between about -14°C and about -16°C for frozen food, lower than or equal to about -18°C for deep-frozen food and close to about -25°C for industrial ice-cream -, the working fluid at the respective thermal user point 5 shall begin expanding at a temperature of between about -32°C and about -38°C.

[0063] Since the temperature at the fresh food conservation unit 8 is typically between about +10°C and about -1°C - in particular, between about +8°C and about +6°C for fruit and vegetables, between about +5°C and about +3°C for dairy products and cold pork and salami and between about +2°C and about 0°C for meat and poultry -, the working fluid at the respective thermal user point 5 shall begin expanding at a temperature of between about -6°C and about -15°C.

[0064] Since the air temperature of the environment A shall be allowed to be adjusted typically between about 16°C (when the environment A is heated during the winter period) and about 25°C (when the environment A is cooled during the summer period) the working fluid at the heat exchanger 10 shall have a temperature of between about +4°C and about +2°C.

[0065] In the preferred embodiment illustrated here, the compression section 3 comprises five compressors 11 allotted to two groups of compressors 11a and 11b, respectively comprising two and three compressors. Such compressors 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, can be of the piston, screw or scroll type, and they are in any case known to those skilled in the art.

[0066] The refrigerating capacities of the compressors 11 can be the same for all of the compressors or different for some or all of them.

[0067] The intake of the compressors 11 of the group of compressors 11a is connected with the line of the thermal user point 5 associated with the operation of the deep-frozen or frozen food conservation unit 7, while the intake of the compressors 11 of the group of compressors 11b is connected with the line of the thermal user point 5 associated with the operation of the fresh food conservation unit 8 and with the line of the thermal user point 5 associated with the operation of the unit 9 for adjusting air temperature.

[0068] At the compression section 3 a plurality of conventional check valves 12 and means for the separation and recovery of oil from the compressors 11 dispersed in the working fluid are also provided. Such means, also conventional and known to those skilled in the art, comprise an oil separator 13, a filter 14 and a line 15 (in figures 1-3 represented as a dotted line) that takes the separated and filtered oil back to the compressors 11. In some embodiments there could also be an oil accumulation reservoir (not shown) placed between the oil separator 13 and the filter 14.

[0069] The thermal exchange device 4 preferably consists of an assembly arranged at the outside E of the environment A where the deep-frozen or frozen food conservation unit 7, the fresh food conservation unit 8 and the unit 9 for adjusting air temperature are active, preferably outside the building comprising environment A. The thermal exchange device 4 allows the thermal exchange of the working fluid with air or other fluid available outside E, such as water (e.g., according to availability and/or requirements, thermal water, river water, ground water, waste water) or another suitable fluid.

[0070] According to the invention, the thermal exchange device 4 comprises a condensing portion 16 and an evaporating portion 17. The evaporating portion 17 is connected with the closed circuit 2 so that, when active (see figure 3 described hereafter), the working fluid reaches it after flowing through the condensing portion 16. As schematically illustrated in figure 4, the condensing portion 16 and the evaporating portion 17 comprise ducts defining respective fluid paths 160 and 170. The fluid paths 160 and 170 are preferably coil-shaped and are embedded in the same assembly of fins 18. The fins 18 are substantially planar and arranged substantially perpendicular to the ducts of the fluid paths 160 and 170. The ducts of the fluid paths 160 and 170 are preferably made of copper; alternatively, the ducts of the fluid paths 160 and 170 could be made of steel. The fins 18 are preferably made of aluminium, possibly surface treated through painting or oxidation or other known processes; alternatively, the fins 18 could be made of copper or iron, possibly surface treated.

[0071] Both the condensing portion 16 and the evaporating portion 17 preferably comprise a plurality of respective fluid paths 160 and 170. In figure 4 just two fluid paths are represented for each portion 16, 17, for the sake of simplicity. In figures 1-3 the condensing portion 16 is diagrammatically represented without specifying in detail the number of fluid paths 160, while the evaporating portion 17 is represented as a group of four fluid paths

170. Each of the fluid paths 170 of the evaporating portion 17 can be selectively intercepted through conventional interception means 171, for example solenoid valves. In embodiments not shown some of the interception means 171 could be left out. Each fluid path 170 of the evaporating portion also has associated with it a respective conventional means 172 for expanding the working fluid, preferably selected from a thermostatic valve and a capillary, more preferably a thermostatic valve, which allows the working fluid flow rate in the respective fluid path 170 to be adjusted.

[0072] The heat exchange device 4 also preferably comprises conventional means 162 for forcedly circulating air or another fluid available outside, such as one or more fans, for example of the helical or centrifugal type, typically electrically actuated. Such means 162 are provided so as to increase the air flow through the thermal exchange device 4 in a preferred direction, indicated by arrows 22. This preferred direction is such that the air crosses the thermal exchange device 4 flowing firstly in contact with the fluid paths 160 of the condensing portion 16 and the respective portions of the fins 18 and then in contact with the fluid paths 170 of the evaporating portion 17 and the respective portions of the fins 18.

[0073] Further interception means 19, 20 and 21, again of the conventional type, for example solenoid valves, are suitably provided in the closed circuit 2, so that the insertion or exclusion of portions thereof is possible both during normal operation, for example to change operating mode, as better described hereafter, and in conditions of failure or of partial stop of the thermal installation 1.

[0074] Means for expanding the working fluid, of the conventional type and preferably selected from thermostatic valves and capillaries, more preferably thermostatic valves, are also arranged in the closed circuit 2 at the thermal user points 5. Figures 1-3 show expansion means 6 at the thermal user point 5 associated with the operation of the unit 9 for adjusting air temperature. In the case of the deep-frozen or frozen food conservation unit 7 and of the fresh food conservation unit 8, the expansion of the working fluid typically takes place at the units 7, 8 themselves and therefore the expansion means 6 are not shown. In alternative embodiments it is nevertheless possible to provide expansion means 6 separate from such units.

[0075] A reversing cycle valve 23 is arranged in the closed circuit 2 to allow switching between different operating modes, as better described hereafter.

[0076] In the closed circuit 2 there are preferably also an accumulation reservoir 24 of the working fluid and a portion defining a double riser 25, which comprises a siphon 251, also known to those skilled in the art under the term "oil trap". Since part of oil from the compressors 11 remains dispersed in the working fluid in the absence of the oil separator 13, but also when it is present, the double riser 25 allows the oil dispersed to be dragged together with the working fluid, and therefore to be returned - through the units 7 and/or 8 - to the compressors 11, substantially in every allowed working fluid flow rate condition in the closed circuit 2, and in particular at minimum flow rates.

[0077] Each of the component elements of the thermal installation 1 described above is preferably designed so as to have a plan overall size not greater than 80 cm by 120 cm, so that the installation 1 can be distributed on one or more standard pallets. The thermal exchange device 4 could also have a larger plan size, if one foresees to install it outside the building. The connection pipelines are preferably made of flexible material and equipped with screwed joints, so as to avoid as far as possible the need for welding *in loco,* thus easing the assembly operations.

[0078] Again with reference to figures 1-3, the operation of the thermal installation 1 shall now be described, according to a preferred embodiment of the thermodynamic process of the invention. In the aforementioned figures the circuit portions active in an operating mode are indicated with a solid line, while the portions not active are indicated with a dashed line. The arrows indicate the path of the working fluid in the closed circuit 2 in each operating mode.

[0079] In a first operating mode, illustrated in figure 1 and typically intended for the intermediate seasons, the thermal installation 1 is active only for producing cold at the deep-frozen or frozen food conservation unit 7 and at the fresh food conservation unit 8. The reversing cycle valve 23 is in a first operating configuration, which allows the delivery of the compressors 11 to be connected directly with the condensing portion 16 of the thermal exchange device 4 through the double riser 25. The interception means 19 and 171 intercept the respective circuit portions, preventing the working fluid from entering the heat exchanger 10 and the evaporating portion 17 of the thermal exchange device 4.

[0080] In this operating mode the working fluid is compressed in the compression section 3 and sent - through the reversing cycle valve 23 and the double riser 25 - to the condensing portion 16, where it condenses releasing heat. Thereafter, the working fluid reaches the accumulation reservoir 24 to be sent to the thermal user points 5 where the deep-frozen or frozen food conservation unit 7 and the fresh food conservation unit 8 are connected. At each of the units 7, 8 the working fluid undergoes a substantially adiabatic expansion and evaporates, absorbing heat from the surroundings and therefore keeping the aforementioned units 7, 8 at the required low temperatures. Such temperatures are typically between about -14°C and about -25°C in the case of the deep-frozen or frozen food conservation unit 7, and between about +10°C and about -1°C in the case of the fresh food conservation unit 8. The flow rate of working fluid circulated in the deep-frozen or frozen food conservation unit 7 is then sent to the intake of the compressors 11 of the group of compressors 11a, while the flow rate of working fluid circulated in the fresh food conservation unit 8 is sent to the intake of the compressors 11 of the group of compressors 11b, thus completing the refrigerating cycle.

[0081] In a second operating mode, illustrated in figure 2 and typically intended for the hot seasons, the thermal installation 1 is active both for producing cold at the deep-frozen or frozen food conservation unit 7 and at the fresh food conservation unit 8, and for cooling the air of one or more rooms of the environment A through the unit 9 for adjusting air temperature. The reversing cycle valve 23 is still in its first operating configuration. The interception means 20 and 171 again intercept the respective circuit portions, preventing the working fluid respectively from by-passing the heat exchanger 10 and from entering the evaporating portion 17 of the thermal exchange device 4. The interception means 19 and 21 are instead open and allow the passage of the working fluid at the thermal user point 5 associated with the operation of the unit 9 for adjusting air temperature, that is through the heat exchanger 10.

[0082] In this operating mode the working fluid is compressed in the compression section 3 and sent, through the reversing cycle valve 23, to the condensing portion 16, where it condenses releasing heat. Thereafter, a first flow rate of the working fluid, through the accumulation reservoir 24, reaches the deep-frozen or frozen food conservation unit 7 and the fresh food conservation unit 8. At these units it undergoes a substantially adiabatic expansion and an evaporation producing cold, and then returns to the compressors 11 completing the refrigerating cycle, as already described with reference to the first operating mode. A second flow rate of the working fluid, thanks to the interception means 19 and 21 being open, flows through the expansion means 6 and reaches the heat exchanger 10. Here the working fluid evaporates, absorbing heat and therefore cooling the thermal carrier fluid circulating in the secondary circuit 91. The unit 9 for adjusting air temperature is thus active for cooling environment A. The flow rate of working fluid coming out from the heat exchanger 10 is then sent, again through the reversing cycle valve 23, to the intake of the compressors 11 of the group of compressors 11b, completing the refrigerating cycle.

[0083] In a third operating mode, illustrated in figure 3 and typically intended for the cold seasons, the thermal installation 1 is active both for producing cold at the deep-frozen or frozen food conservation unit 7 and at the fresh food conservation unit 8, and for heating one or more rooms of the environment A through the unit 9 for adjusting air temperature. The reversing cycle valve 23 is in a second operating configuration, which allows the delivery of the compressors 11 to be directly connected with the thermal user point 5 associated with the air unit 9, that is with the heat exchanger 10. The interception means 19 and 21 intercept the relative circuit portions, respectively preventing the working fluid from passing from the heat exchanger 10 directly to the accumulation reservoir 24 and from the reversing cycle valve 23 directly to the intake of the compressors 11. The interception means 20 and at least one of the interception means 171 are open.

[0084] In this operating mode the working fluid is compressed in the compression section 3 and sent, through the reversing cycle valve 23, to the heat exchanger 10, where it can release sensible superheat and, moreover, partially or totally condense, releasing a first amount of latent heat to the thermal carrier fluid circulating in the secondary circuit 91 associated with the unit 9 for adjusting air temperature. The unit 9 is thus active to heat environment A. Thereafter, again through the reversing cycle valve 23 and the double riser 25, the working fluid is sent to the condensing portion 16, where it possibly completes the condensation releasing a second amount of latent heat. Thereafter, a first flow rate of the working fluid, flowing through the accumulation reservoir 24, reaches the deep-frozen or frozen food conservation unit 7 and the fresh food conservation unit 8. At these units it undergoes a substantially adiabatic expansion and an evaporation, producing cold, and then returns to the compressors 11 of the group of compressors 11a and 11b, substantially completing a heat pump thermal cycle. A second flow rate of working fluid reaches the evaporating portion 17 of the thermal exchange device 4. Based on the number of open interception means 171, this second flow rate flows through one or more of the fluid paths 170, evaporating after having undergone a substantially adiabatic expansion in the respective expansion means 172. The second flow rate of the working fluid coming out from the evaporating portion 17 is then sent to the intake of the compressors 11 of the group of compressors 11b, also in this case substantially completing a heat pump thermal cycle.

[0085] In this operating mode, thanks to the special structure of the thermal exchange device 4 described above and illustrated in figure 4, the amount of heat released by the working fluid during condensation at the condensing portion 16 can be at least partially, and preferably substantially, transferred to the evaporating portion 17 by forced convection of the air and conduction through the fins 18. This contributes both to evaporate the working fluid within the evaporating portion 17, and to delay the possible formation of frost at the fluid paths 170 and at the fins 18. The formation of frost, which is thermally insulating, would hinder the heat exchange with the air of the outside E and therefore would limit to higher values the minimum outside temperature at which the evaporating portion 17 can be active, thus reducing the working range of the thermal installation 1.

[0086] In a variant of the third operating mode described above, it is possible for all of the interception means 171 to be closed and, therefore, for the evaporating portion 17 to be completely excluded from the closed circuit 2. The path and the transformations undergone by the working fluid are substantially the same as those described with reference to the third operating mode, except that the substantially adiabatic expansion and the evaporation with production of cold only occur at the deep-frozen and frozen food conservation unit 7 and at the fresh food conservation unit 8.

[0087] In this variant, the thermal installation 1 is therefore still active both for producing cold at the aforementioned units 7 and 8, and for heating environment A through the unit 9 for adjusting air temperature, but with a reduced heating capacity. In this case, indeed, the amount of heat that the working fluid can release to environment A upon condensation is related to the demand of cold at the units 7 and 8 only.

[0088] This variant of the third operative mode can advantageously be used in all those situations where there is reduced need to heat the environment, as for example can happen at the end of winter or in late autumn. When a greater heating capacity is required it is possible to switch to the third operative mode described above by partially or totally activating the evaporating portion 17. The addition of this thermal load increases the demand of cold in the thermal installation 1 and consequently increases the amount of heat that the working fluid can release upon condensation at the thermal user point 5 associated with the operation of the unit 9 for adjusting air temperature.

[0089] Both the changes in operating mode and the adjustment of the thermal installation 1 in each operating mode are preferably actuated through a microprocessor control unit (not shown in the figures).

[0090] In particular, the control unit receives the following input signals:

- pressure at the intake of the compressors 11 of the group of compressors 11a;
- pressure at the intake of the compressors 11 of the group of compressors 11b;
- pressure at the delivery of the compression section 3;
- temperature of environment A;
- required temperature of environment A;
- possibly, temperature of the thermal carrier fluid of the secondary circuit 91 at the output from the heat exchanger 10.

[0091] Based on the pressure signal at the intake of the compressors 11 of the group of compressors 11a, the control unit determines the thermal load at the deep-frozen or frozen food conservation unit 7 and, if necessary, acts on the number of compressors 11 active in the group of compressors 11a.

[0092] Based on the pressure signal at the intake of the compressors 11 of the group of compressors 11b, the control unit determines the thermal load at the fresh food conservation unit 8 and at the unit 9 for adjusting air temperature when operating in cooling mode, and, if necessary, acts on the number of compressors 11 active in the group of compressors 11b. Based on this signal the control unit can also, in case of thermal load peaks, limit the air cooling function to continue ensuring the correct cooling at the fresh food conservation unit 8.

[0093] Based on the pressure signal at the delivery of the compression section 3, the control unit keeps the condensation of the working fluid within predetermined values for optimal operation of the thermal installation 1, for example by acting on the means 162 for forcedly circulating air at the thermal exchange device 4 (changing the number of active fans or the number of revolutions thereof).

[0094] Based on the temperature signal of environment A and the required temperature signal of environment A, the control unit determines whether the unit 9 for adjusting air temperature must be active in cooling mode, in heating mode, or else does not have to be active. This, in particular, can involve switching the reversing cycle valve 23 and opening/closing the interception means 19 and 21 to switch between the aforementioned modes, and possibly opening/closing the interception means 171, to totally or partially include or exclude the evaporating portion 17 of the thermal exchange device 4 into/from the closed circuit 2.

[0095] Based on the temperature signal of the thermal carrier fluid of the secondary circuit 91 coming out from the heat exchanger 10 and on the required temperature signal of environment A, the control unit adjusts the operation of the unit 9 for adjusting air temperature with respect to the required temperature, for example changing or excluding the thermal carrier fluid flow rate circulating in the respective secondary circuit.

[0096] This last control could, on the other hand, be carried out directly by a control unit of the unit 9 for adjusting air temperature, especially when there are a plurality of units 9 connected with a single secondary circuit 91. In such a case, it is not necessary for the control unit of the installation 1 to receive as an input the temperature signal of the thermal carrier fluid of the secondary circuit 91 at the output of the heat exchanger 10.

[0097] The embodiment of the thermal installation 1 described above can undergo various modifications, which shall not be described here in detail, but in any case fall within the scope of the invention. Such modifications can, for example, comprise: eliminating some or all of the check valves 12; eliminating the means for the separation and recovery of oil from the compressors (oil separator 13, filter 14, line 15); arranging the heat exchange device 4 so that the condensing portion 16 carries out a thermal exchange with air and the evaporating portion 17 with a different fluid, for example water as described above, or vice-versa; actuating the expansion at the evaporating portion 17 by means of a single expansion means 172; arranging the means 162 for forcedly circulating air so as to define a preferred direction of the air flow through the thermal exchange device 4 that is different from and, at the extreme, opposite to that indicated in the figures through the arrows 22, although to the detriment of the performance; leaving out the deep-frozen or frozen food conservation unit 7, the respective thermal user point 5 and the group of compressors 11a, or else leaving out the fresh food conservation unit 8 and the respective thermal user point 5.

[0098] The thermal installation 1 shall in general be marketed without the thermal users (units 7, 8, 9), even if, of course, the operation of the thermal installation 1 requires them to be connected at least at some of the thermal user points 5.

Claims

1. Thermal installation (1), comprising a closed circuit (2) wherein a working fluid carries out a thermodynamic cycle, said closed circuit (2) comprising a plurality of thermal user points (5), at which said working fluid is at a temperature suitable for thermal exchange with at least one unit (9) for adjusting air temperature of an environment (A) and at least one of a deep-frozen or frozen food conservation unit (7) and a fresh food conservation unit (8).

2. Thermal installation (1) according to claim 1, wherein said at least one deep-frozen or frozen food conservation unit (7) is a counter, cabinet or cold-storage room at a temperature between about -14°C and about -25°C.

3. Thermal installation (1) according to any one of the previous claims, wherein said at least one fresh food conservation unit (8) is a counter, cabinet or cold-storage room at a temperature of between about +10°C and about - 1°C.

4. Thermal installation (1) according to any one of the previous claims, wherein said environment (A) is a commercial concern at least partially intended for the sale of food or a dining point.

5. Thermal installation (1) according to any one of the previous claims, wherein said at least one of a deep-frozen or frozen food conservation unit (7)and a fresh food conservation unit (8)directly operate with said working fluid.

6. Thermal installation (1) according to any one of the previous claims, wherein said at least one unit (9) for adjusting air temperature operates with a thermal carrier fluid distinct from said working fluid and in thermal exchange relationship with it at the respective thermal user point (5).

7. Thermal installation (1) according to any one of the previous claims, comprising means for switching (23, 19, 21, 171) between an operating mode wherein said at least one unit (9) for adjusting air temperature cools said environment (A) and an operating mode wherein said at least one unit (9) for adjusting air temperature heats said environment (A).

8. Thermal installation (1) according to claim 7, wherein said means for switching (23, 19, 21, 171) comprise a reversing cycle valve (23) and means (19, 21, 171) for intercepting portions of said closed circuit (2).

9. Thermal installation (1) according to any one of the previous claims, comprising a thermal exchange device (4), at which said working fluid is in thermal exchange relationship with the outside (E) of said environment (A), said thermal exchange device (4) comprising a condensing portion (16), at which said working fluid releases heat, and an evaporating portion (17), at which said working fluid can at least partially, and preferably substantially, absorb said heat released at said condensing portion (16).

10. Thermal installation (1) according to claim 9, wherein said condensing portion (16) comprises at least one first fluid path (160) and said evaporating portion comprises at least one second fluid path (170), said at least one first and at least one second fluid path (160, 170) comprising a plurality of ducts embedded in a same assembly of fin (18).

11. Thermal installation (1) according to claim 10, wherein said thermal exchange device (4) comprises means (162) for forcedly circulating a fluid, preferably air, externally of' said at least one first and at least one second fluid path (160, 170).

12. Thermal installation (1) according to any one of claims 10 or 11, wherein said evaporating portion (17) comprises a plurality of second fluid path (170) connected in parallel and selectively interceptable through a corresponding plurality of interception means (171).

13. Thermal installation (1) according to any one of the previous claims comprising a plurality of compressors (11) defining a compression section (3) of said working fluid, wherein a first group of compressors (11a) of said plurality of compressors (11) has a refrigerating capacity suitable for ensuring the operation of said at least one deep-frozen or frozen food conservation unit (7) and a second group of compressors (11b) of said plurality of compressors (11) has a refrigerating capacity suitable for ensuring the operation of said at least one fresh food conservation unit (8)and of said at least one unit (9) for adjusting air temperature.

14. Thermal installation (1) according to any one of the previous claims, comprising expansion means (6, 172) for expanding said working fluid selected from thermostatic valves and capillaries.

15. Thermal installation (1) according to any one of the previous claims, wherein said working fluid is a re-

frigerating fluid selected from the group comprising hydro-fluoro-carbons (HFC), hydro-chloro-fluoro-carbons (HCFC), carbon dioxide, propane and ammonia.

16. Thermal installation (1) according to claim 15, wherein said refrigerating fluid is a hydro-fluoro-carbon (HFC) selected from the group comprising R-507A and R-404A.

17. Thermal installation (1) according to any one of the previous claims, comprising a microprocessor control unit adapted to control the operation of said thermal installation (1) according to the required operating conditions at said at least one unit (9) for adjusting air temperature and said at least one of a deep-frozen or frozen food conservation unit (7) and a fresh food conservation unit (8).

18. Thermal installation (1) according to any one of the previous claims, wherein each of the component elements thereof has a plan overall size not greater than 80 cm by 120 cm.

19. Thermal exchange device (4) comprising a condensing portion (16), at which a working fluid releases heat, and an evaporating portion (17), at which said working fluid can at least partially, and preferably substantially, absorb the heat released at said condensing portion (16), wherein said condensing portion (16) comprises at least one first fluid path (160) and said evaporating portion (17) comprises at least one second fluid path (170), said at least one first and at least one second fluid paths (160, 170) being embedded in the same assembly of fin (18).

20. Thermodynamic process comprising the step of carrying out a thermodynamic cycle wherein a working fluid reaches, at a plurality of thermal user points (5), a plurality of temperatures suitable for the operation of at least one unit (9) for adjusting air temperature of an environment (A) and at least one of a deep-frozen or frozen food conservation unit (7) and a fresh food conservation unit (8).

21. Process according to claim 20, wherein, in a first operating mode, the operation of said at least one unit (9) for adjusting air temperature is selectively deactivatable.

22. Process according to claim 20, wherein, in a second operating mode, the operation of said at least one unit (9) for adjusting air temperature is for cooling the air temperature.

23. Process according to claim 20, wherein, in a third operating mode, the operation of said at least one unit (9) for adjusting temperature is for heating the air temperature.

24. Process according to claim 23, wherein, in said third operating mode, said step of carrying out a thermodynamic cycle comprises the steps of:

a) compressing said working fluid;
b) placing said working fluid in thermal exchange relationship with said at least one unit (9) for adjusting air temperature, at least partially determining the condensation thereof;
c) substantially completing the condensation of said working fluid; and
d) expanding and evaporating at least part of said working fluid,

wherein in said step d) the working fluid at least partially and preferably substantially absorbs the heat released during said step c).

25. Process according to claim 24 comprising the step of causing a forced flow of a fluid, preferably air, to promote absorption in said step d) of the heat released in said step c).

26. Process according to any one of claims 20 to 25, wherein said step of carrying out a thermodynamic cycle comprises a step of compressing a first flow rate of said working fluid suitable for ensuring the operation of said at least one unit deep-frozen or frozen food conservation (7), and a step of compressing a second flow rate of said working fluid suitable for ensuring the operation of said at least one fresh food conservation unit (8) and of said at least one unit (9) for adjusting air temperature.

27. Process according to claim 26, wherein the operation of said at least one unit (9) for adjusting air temperature is subordinated to the correct operation of said at least one fresh food conservation unit (8).

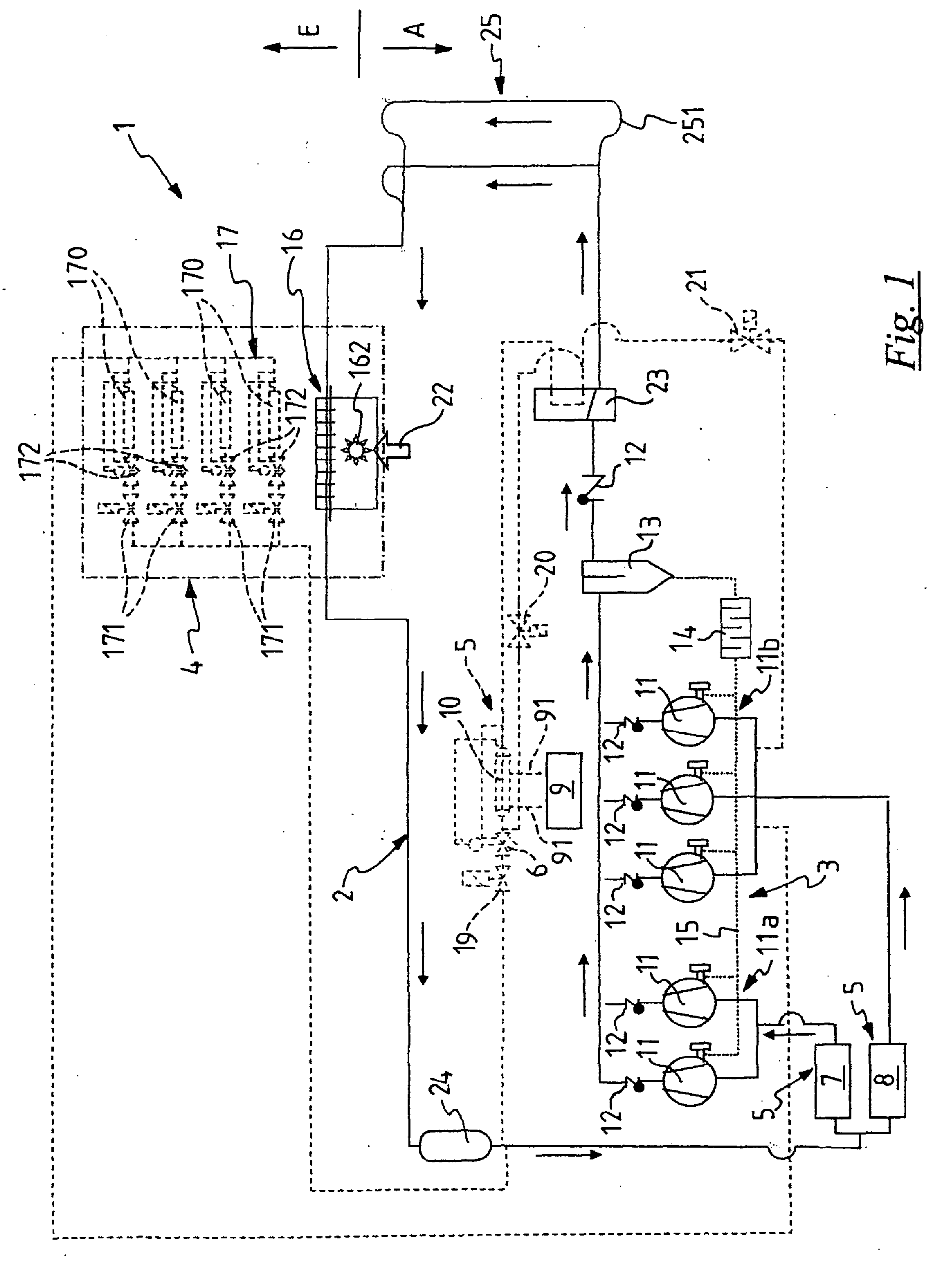
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Fig. 1

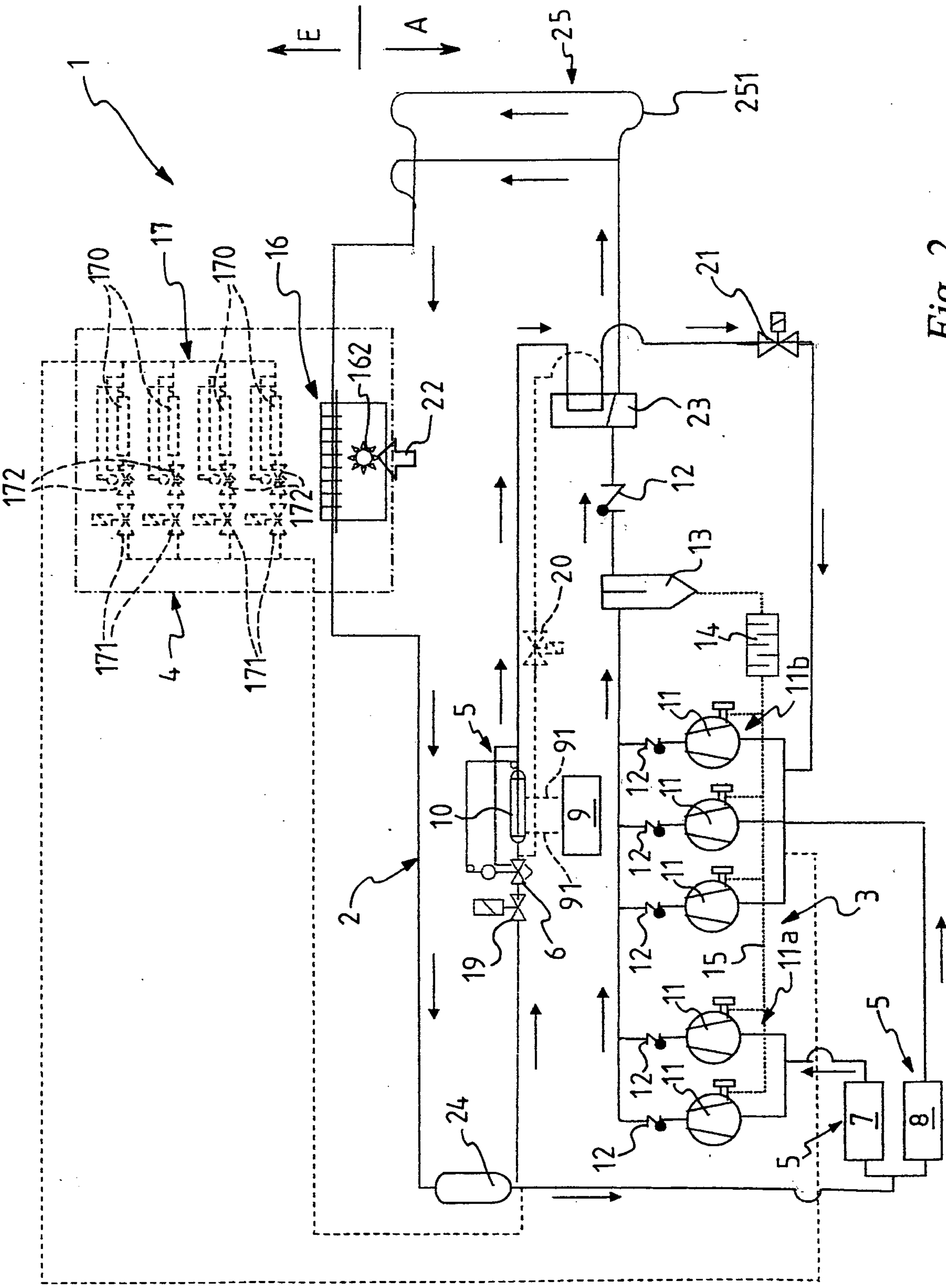
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Fig. 2

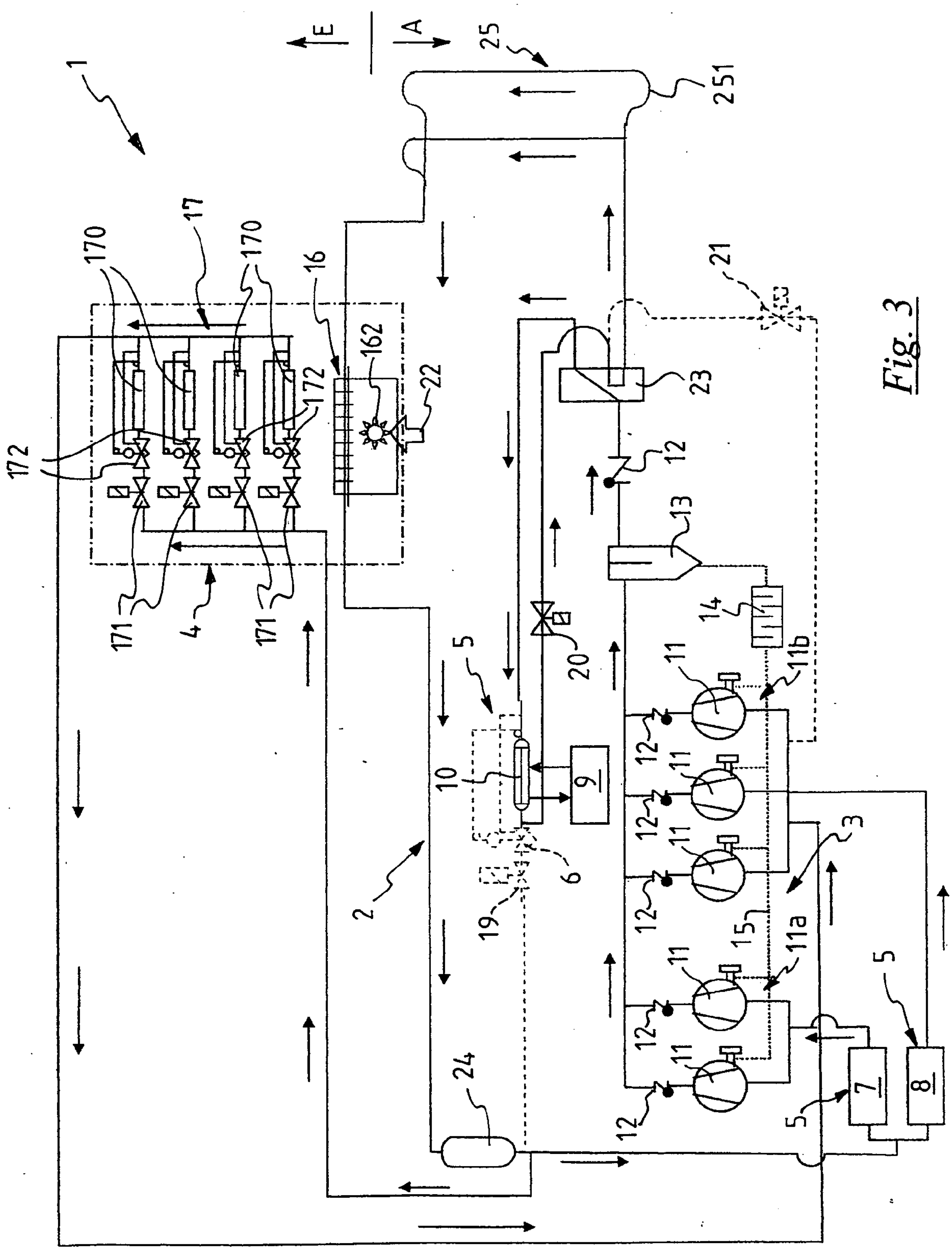
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Fig. 3

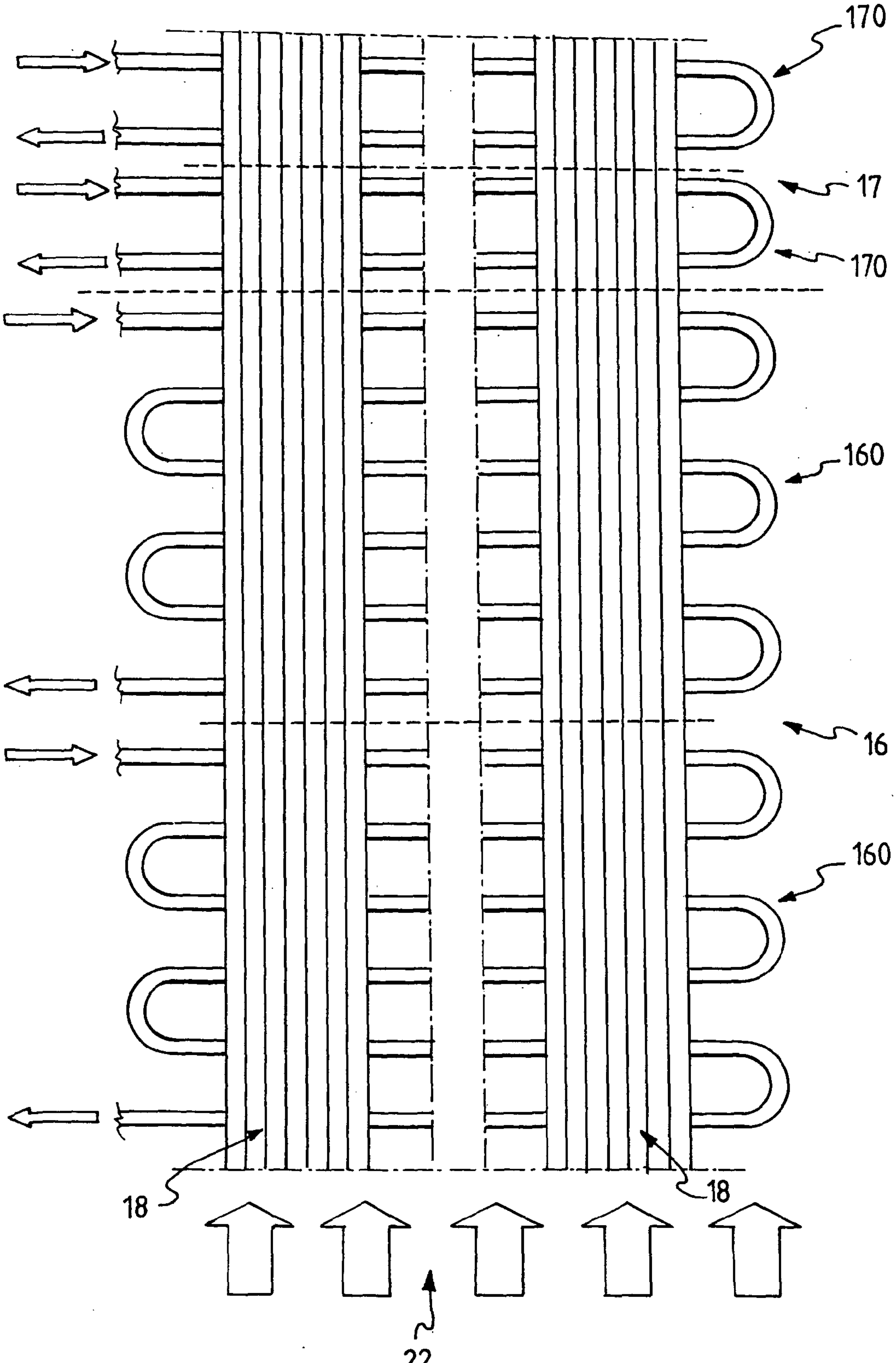

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5423

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* column 8, line 61 - column 11, line 65; figure 1 *	6-11,22	
Y	US 6 668 572 B1 (SEO KOOK-JEONG ET AL) 30 December 2003 (2003-12-30) * column 2, line 55 - column 4, line 65; figures 3A,3B *	6-8,22	
X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 02, 26 February 1999 (1999-02-26) -& JP 10 300271 A (NIPPON LIGHT METAL CO LTD), 13 November 1998 (1998-11-13)	19	
Y	* abstract; figure 6 *	9-11	
X	US 3 905 202 A (TAFT ET AL) 16 September 1975 (1975-09-16) * column 4, line 19 - column 6, line 14; figure 2 *	1,4,5, 13-16, 20,21, 23,27	

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F25D
F25B
F28D
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 November 2005	Zanotti, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 42 5423

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