ABSTRACT

The air exchanger comprises at least one tubular circuit for evaporating a refrigerant and thermally conducting fins (40) fastened to the tubular evaporation circuit and at least one tubular circuit (35) for condensing a refrigerant, which is connected via thermally conducting fins (40) to the evaporation circuit.
REFRIGERATION INSTALLATION FOR COOLING AT LEAST ONE PIECE OF FURNITURE AND/OR A WALK-IN COOLER, AND FOR HEATING AT LEAST ONE ROOM OF PREMISES, AND AN AIR HEAT EXCHANGER FOR SUCH AN INSTALLATION

[0001] The present invention relates to the technical field of refrigeration installations that are used for cooling various substances, and in particular foodstuffs.

[0002] In the above-mentioned field, it is known, in particular in supermarkets, to implement a refrigeration installation comprising high-pressure and low-pressure refrigerant fluid circuits connected to one or more refrigeration units such as reach-in coolers or refrigerated display cabinets, or indeed walk-in coolers. The refrigeration installation further comprises a compression unit that sucks in refrigerant fluid from the low-pressure circuit and delivers it once compressed into the high-pressure circuit. Downstream from the compression unit, the installation further comprises an exterior condenser at which the refrigerant fluid is cooled before being re-directed towards the refrigeration unit or towards an intermediate storage tank. Such an installation is fully satisfactory as regards keeping fragile substances or foodstuffs at low temperature settings. However, the heat extracted from the refrigeration units and resulting from the work of the compression unit is dissipated to the outside, constituting a total loss of energy that, in view of energy costs and of sustainable development requirements, is unsatisfactory.

[0003] In order to remedy that drawback of wasting energy, Patent Application EP 0 431 797 proposes to adopt, in a unit heater, a condenser circuit fed with a gaseous high-pressure refrigerant fluid in such manner as to recover heat for the purpose of heating premises. Unfortunately, the installation proposed by Application EP 0 431 797 does not make it possible to have enough heat to achieve, on its own, satisfactory heating in the winter.

[0004] Patent Application EP 1 921 401 proposes a refrigeration installation from which the extracted heat is recovered for the purpose of heating a heat accumulator that is in communication with a central-heating water circuit and/or with a hot-water circuit. The installation disclosed in Patent Application EP 1 921 401 further comprises an exterior evaporator that, during the winter period, makes it possible to take from the outside the extra heat necessary for satisfying heating needs. During the summer period, the heat extracted by the installation disclosed in EP 1 921 401 is removed mainly to an exterior condenser that is totally independent of the exterior evaporator. Although that installation makes it possible to procure extra heat under satisfactory conditions by operating as a heat pump, it suffers from the drawback of not offering sufficient power to cover the heating needs for heating premises, so that additional electric heater means are provided that are detrimental to the environmental performance of the installation. In addition, that installation makes provision for the evaporator to be defrosted by cycle reversal that also affects the performance of the installation insofar as the design of the exterior evaporator must then result from a compromise between its operating modes as an evaporator and as a condenser. Finally, Patent Application EP 1 921 401 makes provision to place the interior heat exchanger for the heating in series with the exterior condenser, and upstream therefrom, thereby detrimentally affecting the energy efficiency of the installation and requiring a large quantity of refrigerant fluid in the liquid state to fill the circuit downstream from the heat exchanger when the refrigerant fluid is fully condensed therein.

[0005] Thus, the need has arisen for a novel type of refrigeration installation that makes it possible firstly to recover at least a fraction of the heat available from the refrigerant fluid for the purpose of heating premises, and secondly, possibly, to supplement this additional heat under economically and ecologically satisfactory conditions, and that also, for equivalent absorbed electrical power, has performance higher than the performance of known refrigeration installations and lower maintenance costs.

[0006] In order to achieve this object, the invention provides a refrigeration installation having refrigerant fluid and comprising at least:

- [0007] high-pressure and low-pressure circuits;
- [0008] a refrigeration unit comprising at least one evaporator disposed in a piece of furniture or in a walk-in cooler, and connected to the high-pressure and low-pressure circuits;
- [0009] an air-conditioning unit comprising at least one heat exchanger that is disposed inside a room of premises, and that further comprises at least one condenser connected to the high-pressure and low-pressure circuits;
- [0010] an exterior unit comprising at least one air heat exchanger that is disposed outside and that comprises a condensation tube circuit connected to the high-pressure and low-pressure circuits;
- [0011] a main compression unit connected to the high-pressure and low-pressure circuits;
- [0012] an auxiliary compression unit connected to the high-pressure and low-pressure circuits; and
- [0013] a control unit that controls at least operation of the refrigeration installation.

[0014] According to the invention, the refrigeration installation is characterized in that:

- [0015] the air heat exchanger of the exterior unit further comprises:
- [0016] an evaporation tube circuit adapted to be fed with low-pressure refrigerant fluid only and connected to the high-pressure and low-pressure circuits; and
- [0017] thermally conductive fins interconnecting the evaporation tube circuit and the condensation tube circuit by being secured to the evaporation and condensation tube circuit;
- [0018] the condensation tube circuit being adapted to be fed with high-pressure refrigerant fluid only and being dimensioned so as to dissipate all of the heat resulting from keeping each refrigeration unit at temperature settings when a summer temperature prevails outside;
- [0019] the control unit is adapted to place the installation:
- [0020] either in a purely refrigeration operating mode, in which the power of all of the compression units is available for extracting heat from each refrigeration unit only;
- [0021] or in a combined refrigeration and heat pump operating mode, in which the power of the auxiliary compression unit is available for extracting heat from the exterior unit, and the power of each other compression unit is available for extracting heat from each refrigeration unit;
- [0022] the compression units are dimensioned so that their cumulative power is sufficient for maintaining each refrigeration unit at temperature settings when a summer temperature prevails outside and when the installation is in purely refrigeration mode.
[0023] Such a refrigeration installation of the invention is particularly suitable for cooling refrigeration units and for heating a room or some other portion of premises with the heat recovered from the refrigeration units and resulting from the compression of the refrigerant fluid. To this end, implementing an auxiliary compression unit makes it possible, when the heat recovered from the refrigeration units is not sufficient to heat the room satisfactorily, to take from the outside the heat that is lacking and that is necessary to reach the satisfactory heating level.

[0024] In accordance with the invention, the heat exchanger of each air-conditioning unit may be of any suitable type. Thus, the heat exchanger of each air-conditioning unit or of each of some units only, may be a heat exchanger making it possible to heat a heat transfer liquid, such as, for example, but not exclusively, the water of a heating circuit, or indeed the water of a hot-water system. The heat exchanger of each air-conditioning unit, or of each of some units only, may also be an air heat exchanger or "unit heater". Implementing such an air heat exchanger offers the advantage of heating the air directly without using an intermediate heat transfer fluid, and makes it possible to procure optimum efficiency and to simplify implementation and use of the refrigeration installation of the invention. Naturally, the installation of the invention is also suitable for implementing a plurality of air-conditioning units having different types of heat exchanger.

[0025] In addition, implementing an exterior unit designed for making it possible both to remove all of the heat in the summer, and also to recover additional heat in the winter with circuits interconnected by fins makes it possible to obtain a dual-purpose exterior unit that is compact.

[0026] Various embodiments of the installation may be considered. Thus, the high-pressure and low-pressure circuits may comprise a main high-pressure circuit, a secondary high-pressure circuit, and a main low-pressure circuit. The evaporator of the air-conditioning unit is then fed with refrigerant fluid by the main high-pressure circuit via an expansion valve and is connected to the main low-pressure circuit. The evaporation circuit of the exterior unit is fed by the main high-pressure circuit via an expansion valve and is connected to an auxiliary low-pressure circuit, while the condensation circuit of the exterior unit is connected to the main high-pressure circuit upstream from the evaporators. The main compression unit sucks in refrigerant fluid from the main low-pressure circuit and delivers compressed refrigerant fluid to the main high-pressure circuit, while the auxiliary compression unit sucks in refrigerant fluid from the auxiliary compression unit and delivers compressed refrigerant fluid to the main high-pressure circuit.

[0027] The installation may further comprise an isolation valve that is controlled to open or close the communication between the auxiliary low-pressure circuit and the evaporation circuit of the exterior heat exchanger, and a bypass circuit that connects the main low-pressure circuit to the secondary low-pressure circuit and that is equipped with a bypass valve controlled to open or close the bypass circuit. The control unit is then adapted:

- in the purely refrigeration mode, to close the isolation valve and to open the bypass valve, so that the power of the auxiliary compression unit is available for extracting heat from each refrigeration unit only;
- in the combined refrigeration and heat pump operating mode, to open the isolation valve and to close the bypass valve, so that the power of the auxiliary compression unit is available for extracting heat from the exterior unit.

[0028] In a variant of the invention, the control unit is adapted to go from the combined operating mode to the purely refrigeration operating mode and vice versa as a function of the refrigeration needs.

[0029] It should be noted that the large surface area of the condensation circuit, resulting from it being dimensioned to remove heat in the summer, makes it possible to procure very high effectiveness for defrosting the exterior unit while it is operating in combined mode. To this end, in a variant embodiment of the invention, the installation further comprises defrosting means for defrosting the heat exchanger of the exterior unit, which means are adapted so that, when the installation is operating in combined mode, they temporarily feed the condensation circuit of the exterior unit. Implementing such defrosting means makes it possible to preserve the effectiveness of the exterior heat exchanger in particular when said heat exchanger is used as a heat source during the winter period. The use of the condensation circuit, designed to withstand the high pressures of the refrigerant fluid, makes it possible to avoid using defrosting by cycle reversal at the evaporation circuit, thereby offering the advantage firstly of not being obliged to dimension the evaporation circuit for high pressures, and secondly of avoiding subjecting the evaporation circuit to the thermal shock resulting from rapidly going from a negative temperature to a positive temperature, e.g. greater than 30°C and, furthermore, of avoiding the risks of sucking in liquid on re-starting in heat pump mode. In addition, the fins interconnecting the condensation circuit and the evaporation circuit damp the expansion differences between the condensation circuit and the evaporation circuit during defrosting stages, thereby reducing the mechanical stresses to which these circuits are subjected. By separating the evaporation circuit from the condensation circuit in the exterior unit, the invention makes it possible to optimize their dimensioning for their nominal rated operating conditions with acceptable head loss, and fluid speeds that are under control, making it possible for good oil return to be achieved, thereby contributing to the performance of the refrigeration installation as a whole.

[0029] According to a characteristic of the invention, the installation further comprises:

[0030] frost assessment means for assessing the frost on the exterior heat exchanger; and
[0031] at least one controlled valve for feeding the condensation circuit of the air heat exchanger;
[0032] and the control unit is adapted to cause a feed valve for feeding the condensation circuit to open whenever the frost on the heat exchanger exceeds a certain threshold.

[0033] In accordance with the invention, frost detection may be performed in various manners such as, for example, by monitoring the load on a forced-flow fan motor of the heat exchanger so as to deduce from any increase in load on the motor that frost has appeared on the heat exchanger. In another embodiment, the frost assessment means comprises means for measuring the humidity in the air entering and exiting from the heat exchanger.

[0034] In accordance with a characteristic of the invention, the control unit is adapted to reverse the direction of operation of an extractor fan equipping the exterior heat exchanger at the end of defrosting thereof. This rotation reversal makes it possible to obtain optimum drying of the heat exchanger of the exterior unit.
In an embodiment, the installation may be adapted to activities requiring a plurality of low temperature levels, such as, for example, activities in which it is necessary to keep some substances cool at positive temperatures and also to keep some substances frozen at negative temperatures. The refrigeration installation of the invention then further comprises:

- a secondary low-pressure circuit for refrigerant fluid;
- a secondary refrigeration unit comprising at least one evaporator that is disposed in a piece of furniture or in a walk-in cooler, that is fed with refrigerant fluid by the main high-pressure circuit via an expansion valve, and that is connected to the secondary low-pressure circuit; and
- a secondary compression unit that sucks in refrigerant fluid from the secondary low-pressure circuit and that delivers compressed refrigerant fluid into the main high-pressure circuit;

the control unit being adapted to cause the secondary compression unit to operate.

Implementing the secondary compression unit delivering compressed refrigerant fluid to the same main high-pressure circuit as the other compression units makes it possible to use all of the heat energy recovered by all of the compression units for the purposes of heating the room(s) in which the unit heaters are situated.

In accordance with a characteristic of the invention, the auxiliary compression unit power is not sufficient to cool the room under summer outside temperature conditions.

In an embodiment of the invention, at least one unit heater of the air-conditioning unit is adapted to be reversible and to operate as a condenser or as an evaporator, and the installation further comprises means for feeding refrigerant fluid to each unit heater operating as an evaporator.

In a variant of this embodiment, the auxiliary compression unit has sufficient power to cool the room with summer outside temperatures.

The invention also provides an air heat exchanger for a refrigeration installation of the invention, which air heat exchanger comprises:

- a condensation tube circuit adapted to be fed with high-pressure refrigerant fluid only;
- an evaporation tube circuit adapted to be fed with low-pressure refrigerant fluid only; and
- thermally conductive fins interconnecting the evaporation tube circuit and the condensation tube circuit by being secured to the evaporation and condensation tube circuits.

According to the invention, the condensation circuit has heat exchange power that is sufficient to remove heat in the summer period, i.e. the absolute value of the thermal power of the condensation tube circuit is greater than or equal to the absolute value of the thermal power of the evaporation tube circuit.

The heat exchanger of the invention offers the advantage of having an evaporation circuit that is distinct from the condensation circuit so that each of these circuits is appropriately dimensioned for optimally performing its condensing function or its evaporating function, unlike a heat exchanger in which the circuit is adapted for combined operation either as a condenser or as an evaporator. The design of the heat exchanger of the invention thus enables it to procure optimum energy efficiency. In addition, implementing fins that are common to the evaporation circuit and to the condensation circuit makes it possible to optimize the heat exchanges during defrosting that can then be shorter than the defrosting time in a design consisting merely in juxtaposing a condenser and an evaporator one above the other. In addition, as stated above, the fins mechanically damp differential expansion phenomena during defrosting.

According to a characteristic of the invention, the thermal power of the condensation tube circuit has a value lying in the range 1 times the absolute value of the thermal power of the evaporation tube circuit to 5 times said absolute value.

According to another characteristic of the invention, the heat exchange surface area of the condensation tube circuit represents in the range 50% of the sum of the heat exchange surface areas of the condensation and evaporation tube circuits to 80% of said sum.

In an embodiment of the air heat exchanger, under normal conditions of use, the condensation circuit is situated at least in part below the evaporation circuit. This configuration makes it possible to make advantageous use of convection phenomena so as to accelerate defrosting of the evaporation circuit. In another embodiment of the heat exchanger, the condensation circuit and the evaporation circuit comprise loops or tube sheets and certain loops or sheets of the evaporation circuit are superposed on and interleaved between the loops or sheets of the condensation circuit.

In an embodiment of the heat exchanger, the fins extend substantially vertically.

In a variant of the invention, the evaporation and condensation circuits have rectilinear main tubes that are inclined by a few degrees relative to the horizontal, thereby facilitating run-off of water.

In another variant of the invention, the condensation circuit comprises at least one tube sheet that forms the first tube sheet starting from the bottom of the heat exchanger. This first tube sheet advantageously forms a surface on which a fraction of the water present in the air condenses or is deposited, thereby reducing the load of the air flowing in the heat exchanger, and thus reducing the speed at which frost appears on the evaporation circuit.

In accordance with a characteristic of the invention, the heat exchanger further comprises at least one electric fan for forcing the air to flow through the heat exchanger.

Normally the various characteristics, variants, forms and embodiments of the installation and/or of the heat exchanger may be associated with one another in various combinations insofar as they are not mutually incompatible or mutually exclusive.

Furthermore, various other characteristics and advantages of the invention appear from the description given with reference to the accompanying drawings that show non-limiting embodiments of an air heat exchanger and of refrigeration installations of the invention, and in which:

- FIG. 1 is a diagrammatic view of a refrigeration installation of the invention;
- FIG. 2 is a longitudinal section view a heat exchanger of the invention that is suitable for being implemented in the installation shown in FIG. 1;
- FIG. 3 is a cross-section view of the heat exchanger on line III-III of FIG. 2; and
- FIG. 4 is a diagrammatic view of another embodiment of a refrigeration installation of the invention.

A refrigeration installation of the invention, as shown in FIG. 1 and designated overall by reference 1,
includes a main high-pressure refrigerant fluid circuit 2 on which a high-pressure tank 3 is disposed from which a branch 2\textsubscript{p} extends for feeding at least one and generally more main refrigeration units \( R_p \) with high-pressure refrigerant fluid. Such a refrigeration unit \( R_p \) includes at least one evaporator disposed in a piece of furniture or in a walk-in cooler. The evaporator is then fed with refrigerant fluid in the liquid state by the main high-pressure circuit 2\textsubscript{p} via an expansion valve. The evaporator is also connected to a main low-pressure circuit 4. The refrigeration installation 1 also includes at least one and, in the example shown, three air-conditioning units 5 disposed inside one or more rooms of premises. In the example shown, each air-conditioning unit comprises at least one air heat exchanger or unit heater equipped with at least one condenser 6 that is connected to the main high-pressure circuit 2 upstream from the evaporators of the refrigeration units \( R_p \) and, in the example shown, also upstream from the tank 3 of high-pressure refrigerant fluid. The installation 1 also includes a main compression unit 10 that sucks in the refrigerant fluid from the main low-pressure circuit 4 so as to deliver it as compressed into the main high-pressure circuit 2 upstream from the condensers 6, from the high-pressure tank 3, and, naturally, from the evaporators that it feeds. The main compression unit 10 comprises at least one and, in the example shown, three compressors 11 connected in parallel to the high-pressure circuit 2 and to the low-pressure circuit 4. Operation of the compression unit 10 is then controlled by a control unit 12.

[0067] The refrigeration installation as defined above operates in the following manner.

[0068] Since each main refrigeration unit \( R_p \) is provided with an independent regulator device, it causes a valve to open for feeding its evaporator with high-pressure refrigerant fluid via an expansion valve as and when necessary to maintain a setpoint temperature in it. Operation of the refrigeration unit induces an increase in pressure in the main low-pressure circuit 4 that the control unit 12 detects in order to trigger operation of the main compression unit 10 that then sucks in low-pressure refrigerant fluid in a low-pressure gas state so as to deliver it in the high-pressure gas state to the main high-pressure circuit 2. On exiting from the main compression unit 10, the refrigerant fluid finds itself in the main high-pressure circuit 2 in the gas state and at a high temperature of the order of in the range 60° C to 80° C. The invention then proposes to use the heat from the high-pressure refrigerant fluid in the gas state to heat one or more rooms of premises via the unit heaters 5 that have their condensers 6 fed via the valves 13 controlled by the control unit 12. Thus, all of the heat recovered at the refrigeration units is used for heating the rooms of the premises. On exiting from the condensers, the refrigerant fluid is in the high-pressure liquid state. In order to facilitate understanding, those portions of the main high-pressure circuit in which the high-pressure refrigerant fluid is in the gas state are referenced 2\textsubscript{p}, while those portions in which the refrigerant fluid is mainly in the liquid state are referenced 2\textsubscript{l}.

[0069] The heat recovered at the refrigeration units can, in some situations, in particular in the winter period, be insufficient for heating the premises to an acceptable or indeed comfortable setpoint temperature. The term “the winter period” is used to mean a period in which the average outside temperature is less than 18° C. The invention then proposes to take the heat or the calories that are lacking from the outside. To this end, an exterior unit 15 is implemented that comprises at least one heat exchanger 17 that comprises an evaporation circuit 18 connected to the main high-pressure circuit 2 via an expansion valve 19. The evaporation circuit 18 is also connected to an auxiliary low-pressure circuit 20 that feeds an auxiliary compression unit 21. The auxiliary compression unit 21 comprises at least one and, in the example shown, two compressors 22 that are connected in parallel to the auxiliary low-pressure circuit 20 and to the main high-pressure circuit 2. The auxiliary compression unit 20 then sucks in via the auxiliary low-pressure circuit 20 the refrigerant fluid in the gas state coming from the evaporator 18 of the heat exchanger 17 so as to compress it and to deliver it into the main circuit 2. The auxiliary compression unit 20 is then controlled by the control unit 12 that modulates operation of one of or both of the compressors 22 depending on needs. Thus, the auxiliary compression unit 21 and the exterior heat exchanger 5 operate as a heat pump and take from the outside air the extra heat necessary for maintaining the setpoint temperature in the premises by means of the air-conditioning units 5. Thus, the refrigeration installation of the invention makes it possible, by itself, in a combined refrigeration and heat pump operating mode, firstly to cool the refrigeration units and secondly to heat the premises. Such a combined operating mode thus makes it possible to achieve serious energy savings for heating the premises.

[0070] Insofar as the temperature at the surface of the evaporator 18 is negative in view of the expansion of the refrigerant fluid in it, then after a certain operating time, the evaporator 16 is covered in frost coming from condensation and freezing of the water present in the outside atmosphere. It is thus necessary to defrost the condenser 18 regularly.

[0071] The invention proposes to perform this defrosting by using the heat from the compressed refrigerant fluid exiting from the compression units. To this end, the invention proposes to associate a condenser 25 with the evaporator 18. The condenser 25 fed with high-pressure refrigerant fluid by the main high-pressure circuit 2 by being connected thereto firstly downstream from the compression units and secondly upstream from the tank 3 and from the evaporators of the main refrigeration units \( R_p \). In a preferred embodiment and as appears from FIGS. 2 and 3, the evaporator 18 comprises a tube circuit 30 for evaporating the refrigerant fluid, which circuit is formed by tubes 32 comprising rectilinear main tubes as shown more particularly in FIG. 2. In the same way, the condenser 25 comprises a tube circuit for condensing the refrigerant fluid, which circuit is made up of sheets 35 of tubes 36 comprising rectilinear main tubes as shown in FIG. 2. The tubes circuits 30 and 35 are then connected together via thermally conductive fins 40 that, in the example shown, extend substantially vertically. The thermal link by conduction that is provided by the fins 40 that are common to the evaporation circuit 30 and to the condensation circuit 35 guarantees that the defrosting is highly effective. For further optimizing the quality of the heat exchanges and thus the effectiveness of the defrosting in the embodiment shown, the tube sheets of the condensation circuit 35 and of the evaporation circuit 30 are superposed on and interleaved with one another. In addition, in the example shown, the first sheet of the heat exchanger 17 starting from the bottom is formed by tubes of the condensation circuit in such a manner as to form a condensation surface for condensing the water vapor present in the air while the exterior unit 15 is operating. Finally, it can be noted that, in a manner usual for the person skilled in the art, the heat exchanger 17 is situated inside a covered frame 41 equipped at its top with at least one and, in
the example shown, with two fans 43 forcing air to flow through the exterior unit 15. In addition, in order to facilitate removal of the liquid water resulting from the defrosting or from the condensation, the rectilinear portions of the tubes and the fins may be inclined relative respectively to the horizontal and to the vertical by an angle a of a few degrees, e.g. in the range 3° to 5°. This inclination may be obtained by inclining the frame as a whole.

[0072] In the above-explained combined operating mode, it is also possible for provision to be made, when the outside temperature is particularly low, for the compression of the refrigerant fluid coming from the evaporator of the exterior heat exchanger to be staggered. To this end, the installation may have a bypass 55 connecting the outlet of the auxiliary compression unit 21 upstream from the suction inlet of the main compression unit 10 via a constant-pressure cock 56 controlled by the unit 12.

[0073] In addition, while the installation is operating in combined mode, the condenser 25 is used regularly to defrost the evaporator 18. This regular operation can be achieved at predefined time intervals independently of the appearance of any frost on the evaporator 18 or, conversely, be a function of the needs when frost actually appears or a function of the forecast appearance of frost.

[0074] To this end, the refrigeration installation 1 may implement means for assessing the frost. Such frost assessment means may be formed in any suitable manner. For example, the frost assessment means may comprise means 45 for monitoring the load on the fans 43 that, when said load exceeds a predetermined threshold, deduce therefrom that frost has appeared. The frost that deposits on the tubes 30 and on the fins 40 progressively obstructs the heat exchanger 17, making it more difficult for air to flow therethrough so that the load on the fans 43 increases.

[0075] The frost detection means may also comprise a system that measures the humidity of the air entering or leaving the exterior unit 15 so as to deduce therefrom whether any frost has appeared. The frost assessment means may also comprise a system for measuring the humidity and the temperature of the outside air so as to act, as a function of those measurements, to forecast appearance of frost. Naturally, the frost assessment means are connected to the control unit 12 that, whenever necessary, triggers a defrosting cycle.

[0076] During such a defrosting cycle, the unit 12 causes the condenser 25 to be fed with hot high-pressure refrigerant fluid. This feeding is achieved via a branch of the main high-pressure circuit 2 that is controlled by a cock 46 controlled by the unit 12. The cock 46 then makes it possible to admit into the feed circuit of the condenser 25 high-pressure refrigerant gas coming directly from the compression units 10 and 21. In order to avoid a thermal shock that is too large at the heat exchanger 17, it is also possible to provide a bypass line 47 making it possible to take high-pressure refrigerant fluid in the liquid state from downstream from the tank 3. This bypass 47 is then controlled by a cock 48 controlled by the unit 12. Control of the cocks 46 and 48 then makes it possible to mix the high-pressure gas coming from the compression units with the high-pressure fluid coming from the tank 3 so as to modulate the temperature of the fluid in the condenser 25 in order to bring the condenser and the fins progressively from a negative temperature to a positive temperature that is higher but that is less than the temperature of the compressed refrigerant gas exiting from the compression units. Thus, the unit 12 can maintain the temperature of the refrigerant fluid feeding the condenser 25 at values lying approximately in the range 40°C to 60°C, while the maximum temperature at the outlets of the compression units is about 80°C. Such a gradual rise in temperature prevents the heat exchanger 15 from being subjected to a thermal shock that is too large.

[0077] When the defrosting is finished, the unit 12 can also cause the fans 41 to operate in such a manner as to blow the outside air downwards to contribute to drying the heat exchanger 17.

[0078] In the above-described combined refrigeration and heat pump operating mode, the auxiliary compression unit 21 is used to extract heat from the outside environment. However, in accordance with the invention, when it is no longer necessary to heat the premises, e.g. during the summer period, the auxiliary compression unit 21 can be used to reinforce the main compression unit for the purpose of compressing the refrigerant gas coming from the refrigeration units R_p. To this end, the refrigeration installation includes a bypass circuit 50 connecting the main high-pressure circuit 4 to the auxiliary low-pressure circuit 20 via a cock 51 controlled by the unit 12. Upstream from the junction with the bypass 50, the auxiliary low-pressure circuit 20 also has a cock 52 controlled by the unit 12. Thus, in an operating mode that can be said to be a "purely refrigeration" mode, the unit 12 causes the cock 52 to close and the cock 51 to open, and causes the auxiliary compression unit 21 to operate as a function of needs. The power of said auxiliary compression unit is then available for refrigeration, the condenser 25 also being dimensioned to enable the heat extracted from the refrigeration units R_p to be removed to the outside. It can thus be understood that the power of the condenser 25 is then greater than or equal to the power of the evaporator 18. The thermal power of the condensation tube circuit 25 may, for example, have a value lying in the range 1 times the absolute value of the thermal power of the evaporation tube circuit 18 to 5 times said absolute value. This power ratio can be obtained by making the heat exchanger 17 of the exterior unit 15 in such a manner that the heat exchange surface area of the condensation tube circuit 25 represents at least 50% of the sum of the heat exchange surface areas of the condensation and evaporation tube circuits 25 and 18 to 80% of said sum.

[0079] In addition, in purely refrigeration mode, the cocks 45 and 47 are closed, and the condenser 25 is fed via a constant-pressure cock 53 controlled by the unit 12. In addition, in this purely refrigeration operating mode, the evaporator 18 is not fed with refrigerant fluid and the valve and the cock 19 are thus closed. The capacity of the installation of the invention to operate either in combined mode or in purely refrigeration mode makes it possible to dimension the main and auxiliary compression units 10 and 21 with cumulative power just sufficient to guarantee optimum refrigeration in the summer period. The term "the summer period" is used to mean a period during which the average daytime temperature is greater than 18°C. Insofar as, in the winter period, the power necessary for achieving suitable refrigeration is less than the power necessary in the summer period, the residual power available at the auxiliary compression unit 21 may advantageously be used, in the winter period, for operation as a heat pump for heating the premises.

[0080] In the example described with reference to FIG. 1, the refrigeration unit only has main low-pressure and high-pressure refrigeration circuits that feed refrigeration units that operate within the same temperature ranges, either positive or
negative. However, a refrigeration installation of the invention can be required to feed both positive-temperature refrigeration units and also negative-temperature refrigeration units. To this end, and as shown in FIG. 4, an installation of the invention may also have at least one secondary refrigeration unit \( R_2 \), comprising at least one evaporator disposed in a piece of furniture or in a refrigerated room fed with refrigerant fluid by a main high-pressure circuit \( 2 \) downstream from the tank \( 3 \). The evaporator of the secondary refrigeration unit \( R_2 \) is connected to a secondary low-pressure circuit \( 60 \) that feeds a secondary compression unit \( 61 \) sucking in the refrigerant fluid from the secondary low-pressure circuit \( 60 \) so as to deliver it into the main high-pressure circuit \( 2 \). The secondary compression unit \( 61 \) then comprises at least one and, in the example, two compressors \( 62 \) that are controlled by the control unit \( 12 \). Operation of the refrigeration installation of the invention including such a secondary low-pressure circuit \( 60 \) and a secondary compression unit \( 61 \) is then substantially analogous to the operation described above as regards the combined and the purely refrigeration operating modes.

[0081] It should be noted that, in the example shown in FIG. 4, the refrigeration installation includes a liquid heat exchanger \( 63 \) connected firstly to the high-pressure circuit \( 2 \) in parallel with the heat exchangers \( 5 \) and secondly to a circuit \( 64 \) through which a heat transfer liquid flows. The liquid heat exchanger \( 63 \) that is fed under the control of the valve \( 65 \) controlled by the control unit \( UC \) then makes it possible to heat the liquid in the circuit \( 64 \).

[0082] It should also be noted that the condenser \( 25 \) is placed on the main high-pressure circuit \( 2 \) in parallel with the heat exchangers \( 6 \) and \( 63 \). Thus, depending on the operating stages, it is possible to empty the liquid phase of the refrigerant fluid from the non-used circuit portions via suction lines \( 67 \) and \( 68 \) controlled by valves \( 68 \) and \( 69 \) that are controlled by the unit \( 12 \). The suction lines \( 67 \) and \( 68 \) are also connected, via an expansion member \( 70 \), to the low-pressure circuit \( 4 \) immediately upstream from the main compression unit \( 10 \). This configuration makes it possible to reduce the quantity of refrigerant fluid used by the installation compared with installations in which no partial emptying of the liquid phase is possible.

[0083] Naturally, various other modifications may be made to the invention within the ambit defined by the claims.

1-14. (canceled)

15. A refrigeration installation having refrigerant fluid and comprising at least:
- a high-pressure and a low-pressure circuits;
- a refrigeration unit comprising at least one evaporator disposed in a piece of furniture or in a walk-in cooler, and connected to the high-pressure and low-pressure circuits;
- an air-conditioning unit comprising at least one heat exchanger that is disposed inside a room of premises, and that further comprises at least one condenser connected to the high-pressure and low-pressure circuits;
- an exterior unit comprising at least one air heat exchanger that is disposed outside and that comprises a condensation tube circuit connected to the high-pressure and low-pressure circuits;
- a main compression unit connected to the high-pressure and low-pressure circuits;
- a control unit that controls operation of the refrigeration installation;
- wherein the air heat exchanger of the exterior unit further comprises:
  - an evaporation tube circuit adapted to be fed with low-pressure refrigerant fluid only and connected to the high-pressure and low-pressure circuits; and
  - thermally conductive fins interconnecting the evaporation tube circuit and the condensation tube circuit by being secured to the evaporation and condensation tube circuits;
- the condensation tube circuit being adapted to be fed with high-pressure refrigerant fluid only and being dimensioned so as to dissipate all of the heat resulting from keeping each refrigeration unit at temperature settings when a summer temperature prevails outside;
- wherein the control unit is adapted to place the installation:
  - either in a purely refrigeration operating mode, in which the power of all of the compression units is available for extracting heat from each refrigeration unit only;
  - or in a combined refrigeration and heat pump operating mode, in which the power of the auxiliary compression unit is available for extracting heat from the exterior unit, and the power of each other compression unit is available for extracting heat from each refrigeration unit;
- and wherein the compression units are dimensioned so that their cumulative power is sufficient for maintaining each refrigeration unit at temperature settings when a summer temperature prevails outside and when the installation is in purely refrigeration mode.

16. A refrigeration installation according to claim 15, wherein the control unit is adapted to go from the combined operating mode to the purely refrigeration operating mode and vice versa as a function of the refrigeration needs.

17. A refrigeration installation according to claim 15, wherein the control unit is adapted so that, in combined operating mode, it causes the condensation circuit of the exterior unit to be fed in order to defrost the exterior unit.

18. A refrigeration installation according to claim 17, wherein the installation further comprises frost assessment means for assessing the frost on the heat exchanger, and wherein the control unit is adapted to cause the condensation circuit to be fed whenever the frost on the heat exchanger exceeds a certain threshold.

19. A refrigeration installation according to claim 15, wherein the installation further comprises:
- a secondary low-pressure circuit for refrigerant fluid;
- a secondary refrigeration unit comprising at least one evaporator that is disposed in a piece of furniture or in a walk-in cooler, that is fed with refrigerant fluid by the high-pressure circuit, and that is connected to the secondary low-pressure circuit; and
- a secondary compression unit that sucks in refrigerant fluid from the secondary low-pressure circuit (60) and that delivers compressed refrigerant fluid into the high-pressure circuit;
- and wherein the control unit is adapted to cause the secondary compression unit to operate.

20. A refrigeration installation according to claim 15, wherein the absolute value of the thermal power of the condensation tube circuit of the air heat exchanger is greater than or equal to the absolute value of the thermal power of the evaporation tube circuit of the air heat exchanger.
21. A refrigeration installation according to claim 15, wherein the thermal power of the condensation tube circuit of the air heat exchanger has a value lying in the range 1 times the absolute value of the thermal power of the evaporation tube circuit of the air heat exchanger to 5 times said absolute value.

22. A refrigeration installation according to claim 15, wherein the heat exchange surface area of the condensation tube circuit of the air heat exchanger represents in the range 50% of the sum of the heat exchange surface areas of the condensation and evaporation tube circuits to 80% of said sum.

23. An exterior air heat exchanger for a refrigeration installation according to any one of claims 15, said exchanger comprising:

- a condensation tube circuit adapted to be fed with high-pressure refrigerant fluid only;
- an evaporation tube circuit adapted to be fed with low-pressure refrigerant fluid only; and
- thermally conductive fins interconnecting the evaporation tube circuit and the condensation tube circuit by being secured to the evaporation and condensation tube circuits;

- the absolute value of the thermal power of the condensation tube circuit being greater than or equal to the absolute value of the thermal power of the evaporation tube circuit.

24. An exterior air heat exchanger according to claim 23, wherein the thermal power of the condensation tube circuit has a value lying in the range 1 times the absolute value of the thermal power of the evaporation tube circuit to 5 times said absolute value.

25. An exterior air heat exchanger according to claim 23, wherein the heat exchange surface area of the condensation tube circuit represents in the range 50% of the sum of the heat exchange surface areas of the condensation and evaporation tube circuits to 80% of said sum.

26. A heat exchanger according to claims 23, wherein the condensation circuit and the evaporation circuit comprise loops or tube sheets and in that certain loops or sheets of the evaporation circuit are superposed on and interleaved between the loops or sheets of the condensation circuit.

27. A heat exchanger according to claims 23, wherein the fins extend substantially vertically.

28. A heat exchanger according to claim 23, wherein the condensation circuit comprises at least one tube sheet that forms the first tube sheet starting from the bottom of the heat exchanger.

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