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(54) ## FOODSTUFF REFRIGERATING MACHINE

(57) A foodstuff refrigerating machine (1) comprising: a boxlike casing (2) which is provided, on the inside, with a large thermo-insulated compartment (3) adapted to contain the foodstuff product to be preserved; an electrically-operated cooling assembly (6) adapted to cool down what is contained inside the thermo-insulated compartment (3); and an electronic control unit (7) that controls the cooling assembly (6); the cooling assembly (6) being provided with a heat pump unit (10) that uses R744 gas as a refrigerant, and with a refrigerated water source (11) that is connected to the high-pressure heat exchanger ( 12) of the heat pump unit (10) so as to circulate, within said heat exchanger, a flow of refrigerated water or other low-temperature heat-transfer liquid capable of removing heat from the refrigerant.

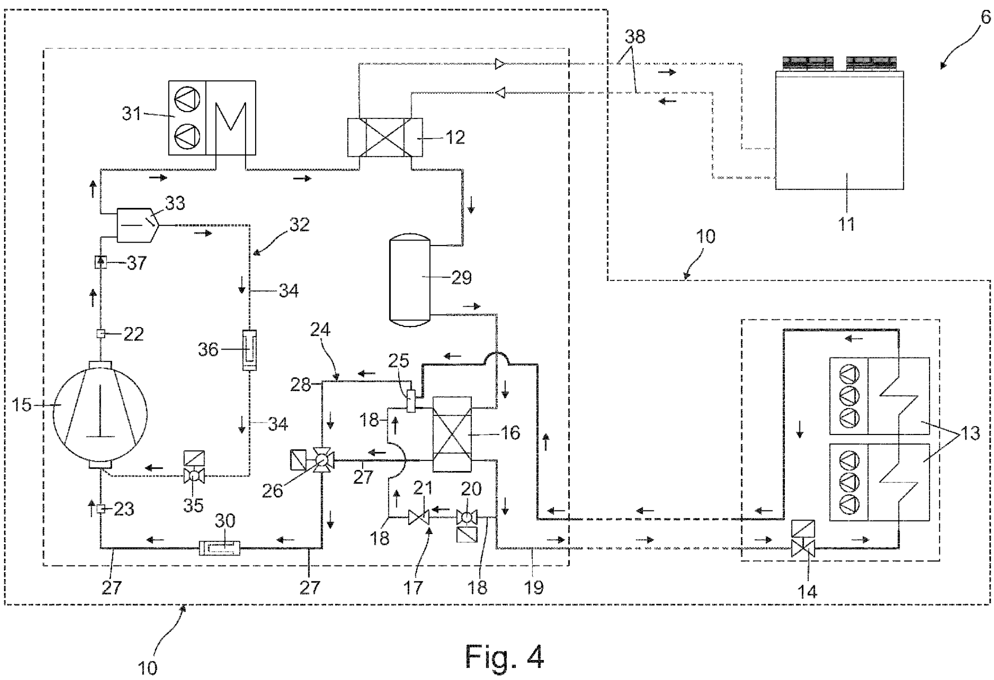


Fig. 4

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## Description

CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This Patent Application claims priority from Italian Patent Application No. 102021000018296 filed on July 12, 2021.

**[0002]** The present invention relates to a foodstuff refrigerating machine.

**[0003]** More in detail, the present invention relates to a blast chiller for foodstuff of a professional type particularly suitable for use in the kitchens of restaurants, canteens, pastry shops and the like. Appliance to which the following disclosure will explicitly refer without thereby losing generality.

**[0004]** As is known, the foodstuff blast chillers are appliances capable of quickly cooling and/or freezing foods and other foodstuff products, even as soon as they have been taken out of the oven, while simultaneously preserving the fragrance, the compactness, the colours and the nutritional values thereof, and more generally all the organoleptic properties.

**[0005]** These professional appliances comprise: an outer boxlike casing, generally substantially parallelepiped in shape and with a self-supporting structure, which is usually made of stainless steel and is provided, on the inside, with a large, substantially parallelepiped-shape, storage chamber or compartment that is suitably thermo-insulated so as to minimise the heat exchange with the outside, is adapted to contain the foodstuff to be treated, and communicates with the outside through a large access opening located on the front face of the boxlike casing; a substantially rectangular -shaped, large door with thermo-insulating structure, which is flag hinged to the outer casing so as to be movable about a vertical axis to and from a closed position, in which the door rests on the front face of the casing in order to more or less hermetically close the access opening to the inner thermo-insulated compartment; and an electrically-operated heat-pump cooling circuit which is capable of cooling down what is contained inside the thermo-insulated compartment.

**[0006]** Unlike traditional refrigerators that are notoriously structured to continuously maintain food at a predetermined temperature usually ranging between +3°C and +6°C, blast chillers are provided with an electronic control unit that drives the heat pump cooling circuit so as to bring, in a predetermined and relatively short time interval, the product contained into the thermo-insulated compartment to a given target temperature usually ranging between -18°C and +3°C, following a predetermined cooling curve that depends on the type of food contained at the moment in the thermo-insulated compartment.

**[0007]** The target temperatures of the cooling process and the relative times are determined by the in-force regulations on hygiene and food safety.

**[0008]** Obviously, in order to quickly cool the food even when it is still at a high temperature and to prevent the formation of ice macro-crystals inside the product, the heat pump cooling circuit must provide performances (cooling capacity) that, with equal storage volume, is significantly higher than the typical performances of traditional refrigerators or freezers.

**[0009]** In addition, the heat pump cooling circuit must also be structured so as to allow the electronic control unit to vary/adjust, albeit in an approximate manner, the temperature of the air that circulates inside the thermo-insulated compartment and skims the food.

**[0010]** To guarantee such performances, the heat pump circuits of the blast chillers currently on the market use, as refrigerant, R452A gas or another gas belonging to the hydrofluorocarbon or HFC family which, although not being toxic and having no effect on the hole in the ozone layer, anyway has a relatively high value of the GWP (acronym for Global Warming Potential) index, with the environmental problems that this entails.

**[0011]** Aim of the present invention is to manufacture a heat pump circuit for professional blast chillers which, on equal efficiency and performances, uses a refrigerant with a lower environmental impact.

**[0012]** In accordance with these aims, according to the present invention there is provided a foodstuff refrigerating machine as defined in Claim 1 and preferably, though not necessarily, in any one of the claims dependent thereon.

**[0013]** The present invention will now be described with reference to the accompanying drawings, which illustrate a non-limiting example embodiment thereof, wherein:

- _ Figure 1 is a perspective view of a foodstuff refrigerating machine realized according to the teachings of the present invention, with parts removed for clarity's sake;
- - Figure 2 is a plan view of the blast chilling cold-room of the refrigerating machine shown in Figure 1, with parts in section and parts removed for clarity's sake;
- - Figure 3 is a perspective view of the condensing unit of the refrigerating machine shown in Figure 1, with parts in section and parts removed for clarity's sake; whereas
- - Figure 4 is a schematic view of the heat pump cooling circuit of the refrigerating machine shown in Figure 1, with parts removed for clarity's sake.

**[0014]** With reference to Figures 1, 2 and 3, reference number 1 denotes, as a whole, a foodstuff refrigerating machine which is capable of rapidly cooling and/or freezing foods and other foodstuff products, also still hot, preferably so as to preserve the fragrance, the compactness, the colours and, more generally, the organoleptic properties of the foodstuff product.

**[0015]** Therefore, the refrigerating machine 1 finds particularly advantageous use in the kitchens of restaurants, canteens, pastry shops and the like.

**[0016]** More in detail, the refrigerating machine 1 is preferably adapted to bring, in a predetermined and relatively short time interval (generally 90-240 minutes), the foods or other foodstuff products placed inside it to a given target temperature generally ranging between -40°C and +40°C, preferably while following a predetermined cooling curve that depends on the temperature and/or on the type of food contained at that moment inside the refrigerating machine 1.

**[0017]** In other words, the refrigeration machine 1 is preferably a professional foodstuff blast chiller that can be advantageously used to quickly freeze foods and other foodstuff products, even when still hot, counteracting bacterial growth and preventing formation of ice macrocrystals inside the product.

**[0018]** With particular reference to Figures 1 and 2, the refrigerating machine 1 firstly comprises: an outer boxlike casing 2, preferably with a rigid self-supporting structure and preferably substantially parallelepiped in shape, which is provided on the inside with a large, preferably substantially parallelepiped in shape, storage chamber or compartment 3 that is suitably thermo-insulated so as to minimise the heat exchange with the outside, is adapted to contain the foodstuff products to be subjected to rapid cooling, and communicates with the outside through a large access opening 4 that is preferably located on the front face of the outer casing 2; and a movable door 5 with thermo-insulating structure, which is adapted to close the access opening 4 preferably substantially hermetically.

**[0019]** More in detail, the door 5 is preferably hinged to the outer casing 2 so as to be able to freely rotate to and from a closed position (see Figures 1 and 2) in which the door 5 closes the access opening 4 to the thermo-insulated compartment 3 preferably substantially hermetically.

**[0020]** In the example shown, in particular, the boxlike casing 2 and the thermo-insulated compartment 3 are preferably substantially rectangular parallelepiped in shape, and the thermo-insulated compartment 3 preferably communicates with the outside through an access opening 4 substantially rectangular in shape.

**[0021]** The door 5, on the other hand, preferably has a substantially rectangular plate-like structure, and is preferably flag hinged to the front face of boxlike casing 2 so as to be able to rotate about a substantially vertical rotation axis A, to and from a closed position (see Figures 1 and 2) in which the door 5 rests on the front face of the boxlike casing 2 and closes, preferably substantially hermetically, the access opening 4 to the thermo-insulated compartment 3.

**[0022]** With reference to Figures 1 to 4, the refrigerating machine 1 moreover comprises: an electrically-operated cooling assembly 6, which is adapted to cool down what is contained inside the thermo-insulated compartment 3 and is preferably also at least partially accommodated inside of the boxlike casing 2; and an electronic control unit 7 which is preferably located outside of the boxlike casing 2, and is adapted to command the cooling assembly 6 preferably depending on the signals coming from one or more temperature sensors (not visible in the figures) that are adapted to detect, continuously or at regular intervals, the temperature inside the thermo-insulated compartment 3.

**[0023]** In addition or as an alternative, the electronic control unit 7 is preferably also adapted to control the cooling assembly 6 depending on the signals coming from one or more portable temperature probes (not visible in the figures) that are adapted to detect, continuously or at regular intervals, the temperature inside the food or other foodstuff temporarily located inside the thermo-insulated compartment 3.

**[0024]** More in detail, the electronic control unit 7 is adapted to drive the cooling assembly 6 so as to bring, in a given time interval preferably, though not necessarily, ranging between 60 and 240 minutes, the temperature measured inside of the thermo-insulated compartment 3 to a predetermined target value preferably ranging between -40°C and +40°C, preferably also causing the temperature of the food or other foodstuff inside the thermo-insulated compartment 3 to reach the target temperature following a cooling curve of predetermined shape.

**[0025]** Clearly, the target temperature and the cooling curve depend on the type of food or other foodstuff present in the thermo-insulated compartment 3 and its initial temperature.

**[0026]** In other words, the value of the target temperature, the time to reach the target temperature and, preferably, also the time course of the temperature inside the thermo-insulated compartment 3 up to the target temperature, i.e. the cooling curve, depend(s) on the type of foodstuff product contained at the moment inside the thermo-insulated compartment 3, and are preferably adapted to preserve the organoleptic properties of the foodstuff product.

**[0027]** Preferably, the value of the target temperature and/or the time to reach the target temperature and/or the cooling curve up to the target temperature is/are moreover manually selected/selectable by the user through a control panel 8 preferably located outside of the boxlike casing 2. Clearly, the control panel 8 may also be located on the external face of the door 5.

**[0028]** More in detail, in the example shown, the electronic control unit 7 is preferably provided with a non-volatile memory where a series of target temperatures, the times for reaching the same target temperature, and a series of cooling curves up to target temperature are stored, each of which is uniquely associated with a type of food; and the user can select the desired target temperature and the time to reach the same target temperature via the control panel 8.

**[0029]** With reference to Figures 1 to 4, the cooling assembly 6 in turn comprises a heat pump unit 10 and a source of refrigerated water at a substantially constant temperature preferably ranging between +4°C and +12°C, which cooperates with the heat pump unit 10 so as to cool down what contained into the thermo-insulated compartment 3.

**[0030]** Preferably, the refrigerated water source is furthermore an electrically-operated hydronic unit 11 which is completely separate and independent from the heat pump unit 10, and is structured so as to supply the heat pump unit 10 with a more or less constant flow of refrigerated water with a substantially constant temperature preferably ranging between +4°C and +12°C. Preferably, the auxiliary hydronic unit 11 is moreover entirely located outside of the boxlike casing 2.

**[0031]** The electronic control unit 7, in turn, is adapted to command the heat pump unit 10 and preferably also the auxiliary hydronic unit 11.

**[0032]** More in detail, with reference to Figures 3 and 4, the cooling circuit of the heat pump unit 10 comprises: a first heat exchanger 12, traditionally called high-pressure heat exchanger or condenser, where the high-pressure refrigerant cools down preferably up to totally passing to the liquid state; a second heat exchanger 13, traditionally called low-pressure heat exchanger or evaporator, where the low-pressure refrigerant heats up preferably to totally passing to the gaseous state; a preferably electrically-operated, gas expansion device 14 which is interposed between the outlet of the high-pressure heat exchanger 12 and the inlet of the low-pressure heat exchanger 13, and is adapted to cause the rapid and irreversible expansion of the refrigerant that flows from the outlet of heat exchanger 12 towards the inlet of heat exchanger 13, so that the refrigerant entering into the heat exchanger 13 has pressure and temperature significantly lower than those of the refrigerant coming out of the heat exchanger 12; and an electrically-operated compressor 15 which is interposed between the heat exchangers 12 and 13, and is adapted to compress the refrigerant that leaves the heat exchanger 13 and returns to the heat exchanger 12, so that the refrigerant coming out of the compressor 15 has temperature and pressure higher than those on entering into the compressor 15.

**[0033]** The high-pressure heat exchanger 12, in addition, is located outside of the thermo-insulated compartment 3 and preferably also outside of the boxlike casing 2, and is hydraulically connected to the refrigerated water source 11 so that the refrigerated water flow coming from the refrigerated water source 11 removes heat from the refrigerant.

**[0034]** In other words, the refrigerated water inlet and outlet of the auxiliary hydronic unit 11 are connected to the high-pressure heat exchanger 12, so as to circulate the refrigerated water inside the heat exchanger 12.

**[0035]** The heat exchanger 13, on the other hand, is preferably located inside the thermo-insulated compartment 3, and is adapted to be skimmed/passed through by the air present/ circulating inside the thermo-insulated compartment 3 so that the air of the thermo-insulated compartment 3 releases heat to the refrigerant.

**[0036]** Differently from the low-pressure heat exchanger 13, the gas expansion device 14 is preferably located outside of the thermo-insulated compartment 3, whereas the compressor 15 is located outside of the thermo-insulated compartment 3 and preferably also outside of the boxlike casing 2.

**[0037]** The cooling circuit of heat pump unit 10 moreover uses gas R744 (carbon dioxide) as refrigerant.

**[0038]** The electronic control unit 7, in turn, commands the compressor 15 and, preferably, also the gas expansion device 14, on the basis of the signals coming from the temperature sensor(s) and/or from the portable temperature probe(s) (not visible in the figures).

**[0039]** In other words, the electronic control unit 7 commands the switching on and off of the compressor 15 depending on the signals coming from the temperature sensor(s) and/or the temperature probe(s).

**[0040]** With reference to Figures 1, 2 and 3, in the example shown, in particular, the high-pressure heat exchanger 12 is preferably a plate heat exchanger.

**[0041]** The low-pressure heat exchanger 13, on the other hand, is preferably a finned-pack heat exchanger. Preferably, the heat pump unit 10 is moreover provided with one or more electrically-operated fans that are located on the finned-pack heat exchanger and are adapted to produce an air flow that skims and/or passes through the heat exchanger.

**[0042]** In addition, the electronic control unit 7 is preferably adapted to activate and deactivate said fan(s) on the basis of the signals coming from the temperature sensor(s) and/or from the portable temperature probe(s) (not visible in the figures).

**[0043]** The gas expansion device 14, on the other hand, is preferably an electrically-operated lamination valve of known type, whereas the compressor 15 is preferably a positive-displacement piston compressor of known type.

**[0044]** With reference to Figures 3 and 4, in addition, the cooling circuit of heat pump unit 10 moreover comprises a supplementary heat exchanger 16, which is preferably located outside of the thermo-insulated compartment 3 and more conveniently outside of the boxlike casing 2, and is adapted to transfer heat from the high-pressure refrigerant directed towards the gas expansion device 14, to the low-pressure refrigerant directed towards the intake of compressor 15, so as to bring to the gaseous state substantially the whole refrigerant directed towards the compressor 15.

**[0045]** More in detail, the heat exchanger 16 is provided with a high-pressure branch and a low-pressure branch. The high-pressure branch of the supplementary heat exchanger 16 is interposed between the outlet of the high-pressure heat exchanger 12 and the gas expansion device 14. On the other hand, the low-pressure branch of the supplementary heat exchanger 16 is interposed between the outlet of the low-pressure heat exchanger 13 and the intake of compressor 15.

**[0046]** In the example shown, in particular, the supplementary heat exchanger 16 is preferably a plate heat exchanger.

**[0047]** With reference to Figures 3 and 4, in addition, the cooling circuit of the heat pump unit 10 moreover comprises a draw-off line 17, which is selectively adapted to divert, towards the inlet of the low-pressure branch of heat exchanger 16, a small part of the high-pressure refrigerant coming out of the high-pressure branch of heat exchanger 16, bypassing the low-pressure heat exchanger 13. In addition, the draw-off line 17 is at the same time adapted to subject the refrigerant that flows along the draw-off line 17 directed towards the low-pressure branch of the supplementary heat exchanger 16, to a rapid and irreversible expansion so as to drastically reduce the temperature and pressure values.

**[0048]** Preferably, the draw-off line 17 is moreover controlled by the electronic control unit 7.

**[0049]** More in detail, the electronic control unit 7 is preferably adapted to activate and deactivate the draw-off line 17 on the basis of the temperature and/or pressure values of the refrigerant measured immediately upstream and/or immediately downstream of compressor 15.

**[0050]** Preferably, the electronic control unit 7 is moreover adapted to command the draw-off line 17, so as to vary/ adjust, in real time, the flowrate of the refrigerant directed towards the low-pressure branch of heat exchanger 16, bypassing the heat exchanger 13.

**[0051]** With reference to Figure 4, in particular the draw-off line 17 preferably comprises: a supplementary pipe 18 that branches off from the pipeline 19 that puts the outlet of the high-pressure branch of the supplementary heat exchanger 16 into communication with the gas expansion device 14, and ends at the inlet of the low-pressure branch of heat exchanger 16, so as to divert/channel, towards the low-pressure branch of the heat exchanger 16, a small part of the high-pressure refrigerant coming out of the high-pressure branch of heat exchanger 16 directed towards the heat exchanger 13; an electrically-operated control valve 20 which is located along the supplementary pipe 18 and is adapted to adjust the flow of the refrigerant directed towards the low-pressure branch of heat exchanger 16; and a lamination member 21 that is located along the supplementary pipe 18 and causes the rapid and irreversible expansion of the refrigerant that flows along the supplementary pipe 18, so as to reduce the pressure and the temperature of the refrigerant directed towards the low-pressure branch of heat exchanger 16.

**[0052]** In the example shown, in particular, the lamination member 21 is preferably a capillary tube of known type. The control valve 20, on the other hand, is preferably structured so as to vary/adjust the flowrate of the refrigerant flowing along pipe 18.

**[0053]** The electronic control unit 7, in turn, is preferably adapted to control the control valve 20 on the basis of the temperature and/or pressure values of the refrigerant flowing out of the compressor 15, and/or on the basis of the temperature and/or pressure values of the refrigerant entering the compressor 15.

**[0054]** In other words, the electronic control unit 7 is adapted to open and close the control valve 20 on the basis of the temperature and/or pressure values of the refrigerant measured immediately upstream and/or immediately downstream of compressor 15.

**[0055]** Preferably, the electronic control unit 7 is moreover adapted to command the control valve 20, so as to vary/adjust the flowrate of the refrigerant directed towards the low-pressure branch of the supplementary heat exchanger 16.

**[0056]** More in detail, with particular reference to Figure 4, the heat pump unit 10 is preferably provided with a temperature and/or pressure sensor 22 that is located immediately downstream of the delivery of compressor 15, and/or a temperature and/or pressure sensor 23 which is located immediately upstream of the intake of compressor 15.

**[0057]** The electronic control unit 7, in turn, is preferably electronically connected to the temperature and/or pressure sensor(s) 22 and/or 23, and is adapted to drive the control valve 20 on the basis of the signals coming from said temperature and/or pressure sensor(s) 22 and/or 23.

**[0058]** In the example shown, in particular, the electronic control unit 7 is preferably programmed/configured so as to open the control valve 20 when the temperature of the refrigerant flowing out of the compressor 15 exceeds a first limit value preferably greater than or equal to +100°C.

**[0059]** In addition or as an alternative, the electronic control unit 7 is preferably programmed/configured so as to open the control valve 20 when the temperature of the refrigerant entering into the compressor 15 exceeds a second limit value preferably greater than or equal to +20°C.

**[0060]** Clearly, the electronic control unit 7 is furthermore programmed/configured so to close the control valve 20 when the temperature of the refrigerant entering and/or leaving the compressor 15 is lower than said first and/or second limit value.

**[0061]** With reference to Figure 4, preferably the cooling circuit of heat pump unit 10 additionally comprises: a gas-liquid separator, which is located immediately upstream of the inlet of the low-pressure branch of supplementary heat exchanger 16, so as to be crossed by the refrigerant directed towards the inlet of the low-pressure branch of supplementary heat exchanger 16, and is adapted to separate the gaseous-state refrigerant from the liquid-state refrigerant while diverting the prevailing part of the gaseous-state refrigerant towards a secondary outlet of the same gas-liquid separator; and an auxiliary pipe that connects the secondary outlet of the gas-liquid separator to the pipeline that puts the outlet of the low-pressure branch of heat exchanger 16 into communication with the intake of compressor 15.

**[0062]** Therefore, the draw-off line 17 is preferably connected to the inlet of the low-pressure branch of supplementary heat exchanger 16, via the interposition of the gas-liquid separator.

**[0063]** More in detail, the cooling circuit of heat pump unit 10 is preferably provided with a bypass line 24, which is arranged in parallel with the low-pressure branch of the supplementary heat exchanger 16, and is adapted to divert at least part of only the gaseous-state refrigerant directly towards the intake of compressor 15, bypassing the low-pressure branch of the heat exchanger 16.

**[0064]** In other words, the by-pass line 24 is preferably interposed between the inlet of the low-pressure branch of supplementary heat exchanger 16 and the intake of compressor 15, and is adapted to divert, towards the intake of compressor 15, at least a part of the gaseous-state refrigerant that comes from the heat exchanger 13 and/or from the draw-off line 17 and is directed towards the inlet of the low-pressure branch of the heat exchanger 16, while instead letting the whole liquid-state refrigerant flow inside the low-pressure branch of supplementary heat exchanger 16.

**[0065]** In the example shown, in particular, the bypass line 24 preferably comprises: a gas-liquid separator 25, which is located immediately upstream of the inlet of the low-pressure branch of supplementary heat exchanger 16 so as to be crossed by the refrigerant coming from the heat exchanger 13 and/or from the draw-off line 17, and is adapted to separate the gaseous-state refrigerant from the liquid-state refrigerant and to divert the major part of the gaseous-state refrigerant towards a secondary outlet of the same gas-liquid separator 25; a static or dynamic three-way mixing member 26 which is located along the pipeline 27 that puts the outlet of the low-pressure branch of heat exchanger 16 into communication with the intake of compressor 15; and an auxiliary pipe 28 that connects the secondary outlet of the gas-liquid separator 25 to the mixing member 26, so as to convey the gaseous-state refrigerant to the mixing member 26 and introduce the refrigerant into the pipeline 27, downstream of the supplementary heat exchanger 16.

**[0066]** The three-way mixing member 26 is adapted to channel, towards the intake of compressor 15, both the gaseous-state refrigerant coming from the outlet of the low-pressure branch of supplementary heat exchanger 16, and the gaseous-state refrigerant coming from the gas-liquid separator 25.

**[0067]** Preferably, the mixing member 26 is moreover structured so as to be able to adjust/vary the amount of gaseous-state refrigerant coming from the gas-liquid separator 25 and the amount of gaseous-state refrigerant coming from the low-pressure branch of heat exchanger 16.

**[0068]** In the example shown, in particular, the mixing member 26 preferably consists of an electrically-operated three-way mixing valve that is preferably controlled by the electronic control unit 7, and is able to adjust/vary the ratio between the flowrate of the gaseous-state refrigerant coming from the gas-liquid separator 25, and the flowrate of the gaseous-state refrigerant coming from the low-pressure branch of heat exchanger 16.

**[0069]** Clearly in a less sophisticated embodiment, the mixing member 26 may also consist of a manually-operated three-way mixing valve. In this case, the fraction of refrigerant coming from the gas-liquid separator 25 and the fraction of refrigerant coming from the heat exchanger 16 are manually adjusted by the technician.

**[0070]** With reference to Figures 3 and 4, the cooling circuit of heat pump unit 10 preferably moreover comprises a pressurized tank 29, which has a nominal capacity preferably ranging between 1 and 100 litres, and is located between the outlet of the high-pressure heat exchanger 12 and the inlet of the high-pressure branch of supplementary heat exchanger 16, so as to be able to accumulate a given amount of liquid- and/or gaseous-state refrigerant coming from the high-pressure heat exchanger 12.

**[0071]** Preferably, the cooling circuit of heat pump unit 10 is additionally provided with a filtering member 30, which is located along the pipeline 27 connecting the outlet of the low-pressure branch of supplementary heat exchanger 16 to the intake of compressor 15, preferably immediately downstream of mixing member 26, and is adapted to retain the impurities present in the flow of refrigerant directed towards the intake of compressor 15.

**[0072]** With reference to Figure 4, additionally the cooling circuit of heat pump unit 10 preferably also comprises an auxiliary heat-exchanger 31 that is located between the delivery of the compressor 15 and the inlet of the high-pressure heat exchanger 12, and is adapted to cool down the high-pressure refrigerant directed towards the heat exchanger 12.

**[0073]** Preferably, the auxiliary heat exchanger 31 is furthermore located outside of the thermo-insulated compartment 3, and is adapted to be skimmed/crossed by the air present outside of the refrigerating machine 1, so that the external air removes heat from the high-pressure refrigerant.

**[0074]** In the example shown, in particular, the auxiliary heat exchanger 31 is preferably a finned-pack heat exchanger and is preferably located outside the boxlike casing 3.

**[0075]** Preferably, the heat pump unit 10 is additionally provided with one or more electrically-operated fans (not visible in the figures) that are located on the finned-pack heat exchanger and are adapted to produce an air flow that skims and/or crosses the heat exchanger.

**[0076]** The electronic control unit 7, in addition, is preferably adapted to activate and deactivate the fan or fans of the auxiliary heat exchanger 31 on the basis of some operating parameters of the refrigerating machine 1.

**[0077]** More in detail, the electronic control unit 7 is preferably adapted to activate and deactivate the fan or fans of auxiliary heat exchanger 31 on the basis of the refrigerant temperature detected immediately downstream of the auxiliary heat exchanger 31 and/or of the outside air.

**[0078]** In other words, the electronic control unit 7 is preferably adapted to activate and deactivate the fan or fans of auxiliary heat exchanger 31 on the basis of the signals coming from a temperature sensor present on the auxiliary heat exchanger 31.

**[0079]** With reference to Figure 4, preferably the cooling circuit of heat pump unit 10 furthermore includes an oil recovery line 32, which connects the delivery of compressor 15 to the intake of the same compressor 15, and is adapted to retain and channel again towards the intake of compressor 15 most of the oil drops that are suspended in the high-pressure refrigerant flowing out of compressor 15.

**[0080]** The oil recovery line 32 preferably comprises: an oil separator 33, which is located downstream of the delivery of compressor 15 so as to be crossed by the refrigerant directed towards the high-pressure heat exchanger 12, and is adapted to retain the oil drops in suspension in the refrigerant; a return pipe 34 that connects the oil outlet of the oil separator 33 to the intake of compressor 15, so as to direct/ channel the oil accumulating into the oil separator 33, again towards the intake of compressor 15; an electrically-operated shut-off valve 35, which is located along pipe 34 and is adapted to adjust the oil flow towards the intake of compressor 15; and optionally also a second filtering member 36, which is located along the pipe 34, upstream of the shut-off valve 35, and is adapted to retain the impurities present in the oil directed towards the intake of compressor 15.

**[0081]** The liquid oil that accumulates in the oil separator 33 is pushed towards the intake of compressor 15 by the difference in pressure existing between the delivery and the intake of compressor 15.

**[0082]** The electronic control unit 7, in addition, is preferably adapted to also control the shut-off valve 35, so as to introduce, preferably at more or less regular intervals, small amounts of oil into the flow of low-pressure refrigerant entering into the compressor 15.

**[0083]** With reference to Figure 4, preferably the cooling circuit of heat pump unit 10 is furthermore provided with a non-return valve 37 which is located between the delivery of compressor 15 and the high-pressure heat exchanger 12, and is oriented so as to allow the refrigerant to flow exclusively in direction of heat exchanger 12.

**[0084]** With reference to Figures 1, 2, 3 and 4, preferably the heat pump unit 10 is finally divided into an evaporating module and a condensing module, suitably connected by means of specific pipes.

**[0085]** The evaporating module of heat pump unit 10 comprises the low-pressure heat exchanger 13 and the gas expansion device 14, and is preferably located inside the thermo-insulated compartment 3.

**[0086]** The condensing module of heat pump unit 10, on the other hand, comprises the high-pressure heat exchanger 12, the compressor 15, the supplementary heat exchanger 16, the draw-off line 17, the bypass line 24, the pressurized tank 29, the auxiliary heat exchanger 31, if present, and the remaining components of the cooling circuit of heat pump unit 10, and is preferably located on an easily transportable self-supporting structure 40, preferably made of metal material and preferably with a boxlike structure, which is completely separate and distinct from the boxlike casing 2, and is adapted to stably rest on and optionally be anchored to the ground outside and away from the boxlike casing 2.

**[0087]** With reference to Figures 1 and 4, the auxiliary hydronic unit 11, on the other hand, preferably consists of an air-water heat-pump apparatus of known type, and is preferably connected to the high-pressure exchanger 12 of the heat pump unit 10 by means of a pair of connecting pipes 38 of appropriate length.

**[0088]** Similarly to the condensing module of heat pump unit 10, furthermore the auxiliary hydronic unit 11 is preferably structured so as to stably rest on and optionally be anchored to the ground away from the boxlike casing 2.

**[0089]** Being a component readily available on the market, the air-water heat-pump apparatus won’t be further described.

**[0090]** General operation of refrigerating machine 1 is easily inferable from what written above.

**[0091]** The heat pump unit 10 removes heat from what contained into the thermo-insulated compartment 3, and transfers said heat to the refrigerated water coming from the auxiliary hydronic unit 11 which, in turn, transfers the heat to the external environment.

**[0092]** The cooling circuit of heat pump unit 10, on the other hand, is specifically designed to be able to use R744 gas (carbon dioxide) as refrigerant.

**[0093]** The supplementary heat exchanger 16, in fact, transfers the heat from the high-pressure refrigerant directed towards the gas expansion device 14 to the low-pressure refrigerant directed towards the intake of compressor 15, so as to bring all the R744 gas (carbon dioxide) directed towards the intake of compressor 15 to the gaseous state.

**[0094]** The draw-off line 17, on the other hand, is able to introduce low-pressure and low-temperature refrigerant, not necessarily all in the liquid state, in the low-pressure branch of supplementary heat exchanger 16, so as to lower the nominal temperature of the R744 gas (carbon dioxide) that reaches the intake of compressor 15.

**[0095]** During operation of refrigerating machine 1, in fact, the temperature of the R744 gas (carbon dioxide) leaving the low-pressure heat exchanger 13 varies/fluctuates freely depending on the quantity and/or the current temperature of the foodstuff product placed into the thermo-insulated compartment 3.

**[0096]** The electronic control unit 7 commands the draw-off line 17 so that the temperature of the R744 gas (carbon dioxide) entering the compressor 15, even if fluctuating freely like the evaporation temperature on exit of the low-pressure heat exchanger 13, never reaches values that are too high and such as to jeopardize the operation of compressor 15.

**[0097]** More in detail, the electronic control unit 7 preferably commands the draw-off line 17 depending on the signals coming from the temperature and/or pressure sensors 22 and/or 23, so as to stably maintain the temperature of the R744 gas (carbon dioxide) entering the compressor 15 below a given limit value preferably lower +25°C.

**[0098]** The advantages connected to the particular structure of the cooling assembly 6 are remarkable.

**[0099]** Firstly, the use of R744 gas (carbon dioxide) as refrigerant inside the cooling circuit of heat pump unit 10 drastically reduces the value of the GWP index of the machine.

**[0100]** In addition, the particular structure of the cooling circuit of heat pump unit 10 allows to overcome the operating limits imposed by the R744 gas (carbon dioxide), and to provide performances (cooling capacity) compatible with use inside the professional foodstuff blast chillers.

**[0101]** Finally, experimental tests have shown that the use of R744 gas (carbon dioxide) and the particular structure of the cooling circuit increase the overall efficiency of the cooling assembly 6, with the savings this entails.

**[0102]** More in detail, the draw-off line 17 prevents the temperature of the R744 gas (carbon dioxide) entering the compressor 15 from reaching temperatures so high as to rapidly cause the compressor 15 to break due to destructive overheating.

**[0103]** It is finally clear that modifications and variations may be made to the above-described refrigerating machine 1 without however departing from the scope of the present invention.

**[0104]** For example, the high-pressure heat exchanger 12 may be a tube-in-tube heat exchanger.

**[0105]** Similarly, the supplementary heat exchanger 16 may be a tube-in-tube heat exchanger.

**[0106]** In addition, in a more sophisticated and not illustrated embodiment, the control valve 20 and the lamination member 21 of draw-off line 17 may be integrated into an electrically -operated lamination valve.

**[0107]** In this case, the electronic control unit 7 is preferably adapted to also control this second lamination valve.

**[0108]** Lastly, the refrigerated water that the refrigerated water source, or rather the auxiliary hydronic unit 11, circulates inside the high-pressure heat exchanger 12, may be replaced by glycol, by a mixture of water and glycol, or by another low-temperature heat-transfer liquid, with a substantially constant temperature and preferably between +4°C and +12°C.

## Claims

1. A foodstuff refrigerating machine (1) comprising: a boxlike casing (2) which is provided, on the inside, with a large thermo-insulated compartment (3) adapted to contain the foodstuff product to be preserved; an electrically-operated cooling assembly (6) adapted to cool down what contained inside the thermo-insulated compartment (3); and an electronic control unit (7) that commands the cooling assembly (6);

    the cooling assembly (6) being provided with a heat-pump unit (10) that comprises: a high-pressure heat exchanger (12) where the high-pressure refrigerant cools down; a low-pressure heat exchanger (13) where the low-pressure refrigerant heats up; a gas expansion device (14) that is interposed between the outlet of the high-pressure heat exchanger (12) and the inlet of the low-pressure heat exchanger (13), and is adapted to cause the rapid expansion of the refrigerant that flows from the high-pressure heat exchanger (12) towards the low-pressure heat exchanger (13); and a compressor (15) which is interposed between the high-pressure heat exchanger (12) and the low-pressure heat exchanger (13), and is adapted to compress the refrigerant that flows out of the low-pressure heat exchanger (13) and returns to the high-pressure heat exchanger (12);

    said refrigerating machine (1) being **characterised in that** the heat pump unit (10) additionally comprises: a supplementary heat exchanger (16) provided with a high-pressure branch crossed by the refrigerant directed from the high-pressure heat exchanger (12) to the gas expansion device (14), and with a low-pressure branch crossed by the refrigerant directed from the low-pressure heat exchanger (13) to the compressor intake (15), so as to transfer heat from the high-pressure refrigerant directed towards the gas expansion device (14) to the low-pressure refrigerant directed towards the compressor intake (15); and a draw-off line (17) which is adapted to selectively divert, towards the inlet of the low-pressure branch of the supplementary heat exchanger (16), a part of the high-pressure refrigerant flowing out of the high-pressure branch of the supplementary heat exchanger (16), simultaneously subjecting said refrigerant to a rapid expansion in order to reduce both temperature and pressure; and **in that** the electronic control unit (7) controls said compressor (5) and said draw-off line (17) .

2. The refrigerating machine according to Claim 1, wherein the electronic control unit (7) controls the draw-off line (17) based on the temperature and/or pressure values of the refrigerant entering and/or exiting said compressor (15) .

3. The refrigerating machine according to Claim 1 or 2, wherein the electronic control unit (7) controls the draw-off line (17) so as to vary/adjust the flowrate of the refrigerant directed towards the low-pressure branch of the supplementary heat exchanger (16)

while bypassing the low-pressure heat exchanger (13).

**4.** The refrigerating machine according to any one of the preceding claims, wherein said draw-off line (17) comprises: a first supplementary pipe (18) that branches-off from a first pipeline (19) that puts the outlet of the high-pressure branch of the supplementary heat exchanger (16) into communication with the gas expansion device (14), and ends at the inlet of the low-pressure branch of the supplementary heat exchanger (16); an electrically-operated control valve (20) that is located along said first supplementary pipe (18) and is adapted to adjust the flow of the refrigerant flowing towards said low-pressure branch; and a lamination member (21) that is located along the first supplementary pipe (18) and causes the rapid expansion of the refrigerant that flows along said first supplementary pipe (18).

**5.** The refrigerating machine according to Claim 4, wherein said control valve (20) is capable of regulating the flowrate of the refrigerant flowing along said first supplementary pipe (18).

**6.** The refrigerating machine according to any one of the preceding claims, wherein the heat pump unit (10) additionally comprises a bypass line (24), which is arranged in parallel to the low-pressure branch of the supplementary heat exchanger (16), and is adapted to divert at least part of the gaseous-state refrigerant towards the compressor intake (15), while bypassing the low-pressure branch of the supplementary heat exchanger (16).

**7.** The refrigerating machine according to Claim 6, wherein the bypass line (24) comprises: a gas-liquid separator (25), which is located upstream of the inlet of the low-pressure branch of the supplementary heat exchanger (16) so as to be passed through by the refrigerant coming from the low-pressure heat exchanger (13) and/or from the draw-off line (17), and is adapted to separate the gaseous-state refrigerant from the liquid-state refrigerant while diverting at least part of the gaseous-state refrigerant towards a secondary outlet of the same gas-liquid separator (25); a three-way mixing member (26) which is located along a second pipeline (27) that puts the outlet of the low-pressure branch of said supplementary heat exchanger (16) into communication with the compressor intake (15); and a second auxiliary pipe (28) that connects the secondary outlet of the gas-liquid separator (25) to said mixing member (26), so as to convey the gaseous-state refrigerant to the mixing member (26).

**8.** The refrigerating machine according to Claim 7, wherein said mixing member (26) is a three-way mixing valve.

**9.** The refrigerating machine according to any one of the preceding claims, wherein the heat pump unit (10) additionally comprises a pressurized tank (29) which is located between the outlet of the high-pressure heat exchanger (12) and the inlet of the high-pressure branch of the supplementary heat exchanger (16), so as to be able to accumulate some liquid- and/or gaseous- state refrigerant coming from the high-pressure heat exchanger (12).

**10.** The refrigerating machine according to any one of the preceding claims, wherein the heat pump unit (10) additionally comprises an auxiliary heat-exchanger (31) that is located between the delivery of the compressor (15) and the inlet of the high-pressure heat exchanger (12), and is adapted to cool down the high-pressure refrigerant directed towards the high-pressure heat exchanger (12).

**11.** The refrigerating machine according to any one of the preceding claims, wherein the refrigerant is R744 gas.

**12.** The refrigerating machine according to any one of the preceding claims, wherein the cooling assembly (6) is additionally provided with a refrigerated water source (11) that is connected to the high-pressure heat exchanger (12) so as to circulate, within said high-pressure heat exchanger (12), a flow of refrigerated water or other low-temperature heat-transfer fluid capable of removing heat from the refrigerant.

**13.** The refrigerating machine according to Claim 12, wherein said refrigerated water source is an air-water heat-pump apparatus (11), and is adapted to circulate, within the high-pressure heat exchanger (12), a flow of water or other heat-transfer liquid with a temperature substantially constant and preferably ranging between +4°C and +12°C.

**14.** The refrigerating machine according to any one of the preceding claims, wherein the high-pressure heat exchanger (12) is a plate heat exchanger and/or wherein the supplementary heat exchanger (16) is a plate heat exchanger.

**15.** The refrigerating machine according to any one of the preceding claims, wherein at least the high-pressure heat exchanger (12), the compressor (15), the supplementary heat exchanger (16) and the draw-off line (17) are placed on a self-supporting structure (40) which is separate and distinct from the boxlike casing (2) and is adapted to stably rest on the ground outside said boxlike casing (2).

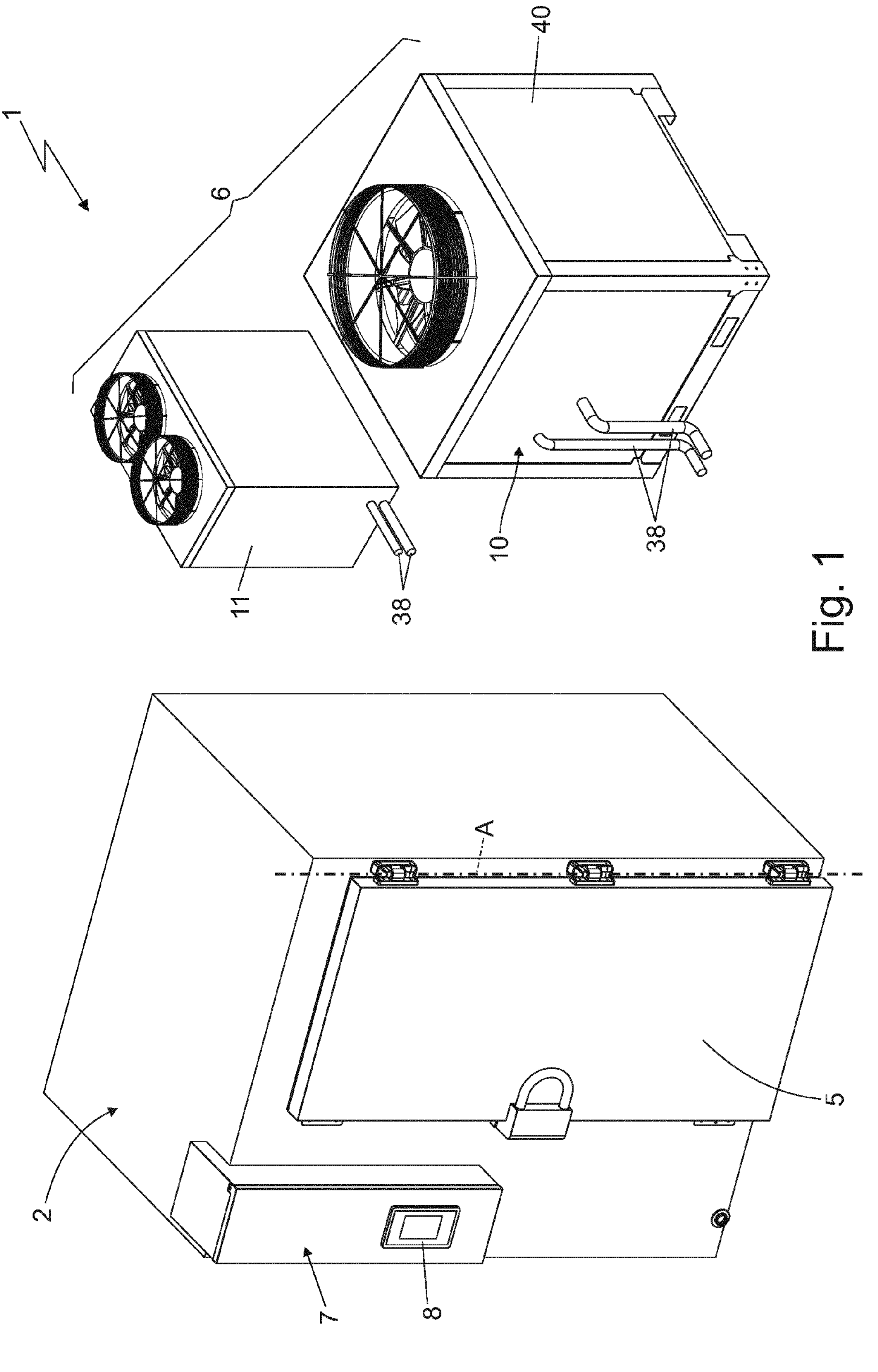


Fig. 1

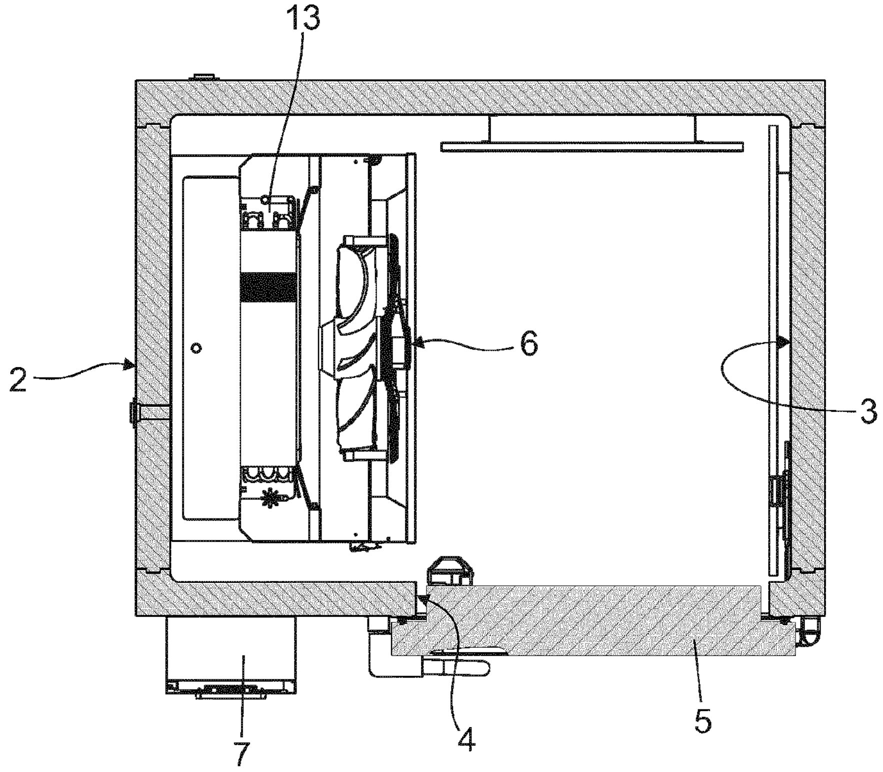


Fig. 2

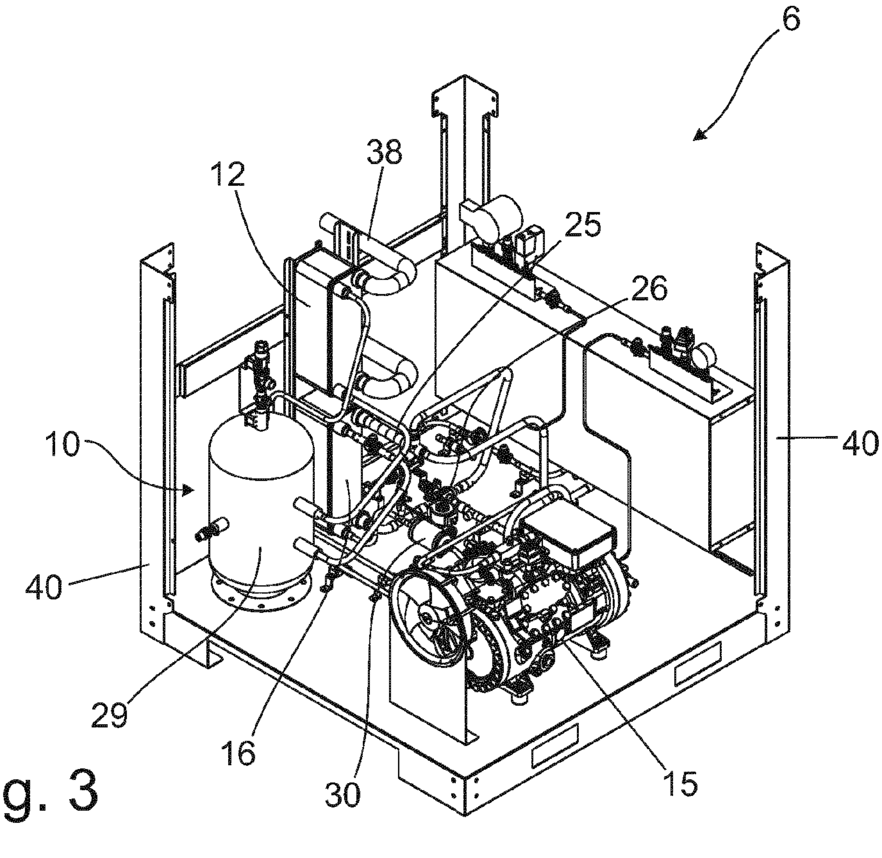


Fig. 3

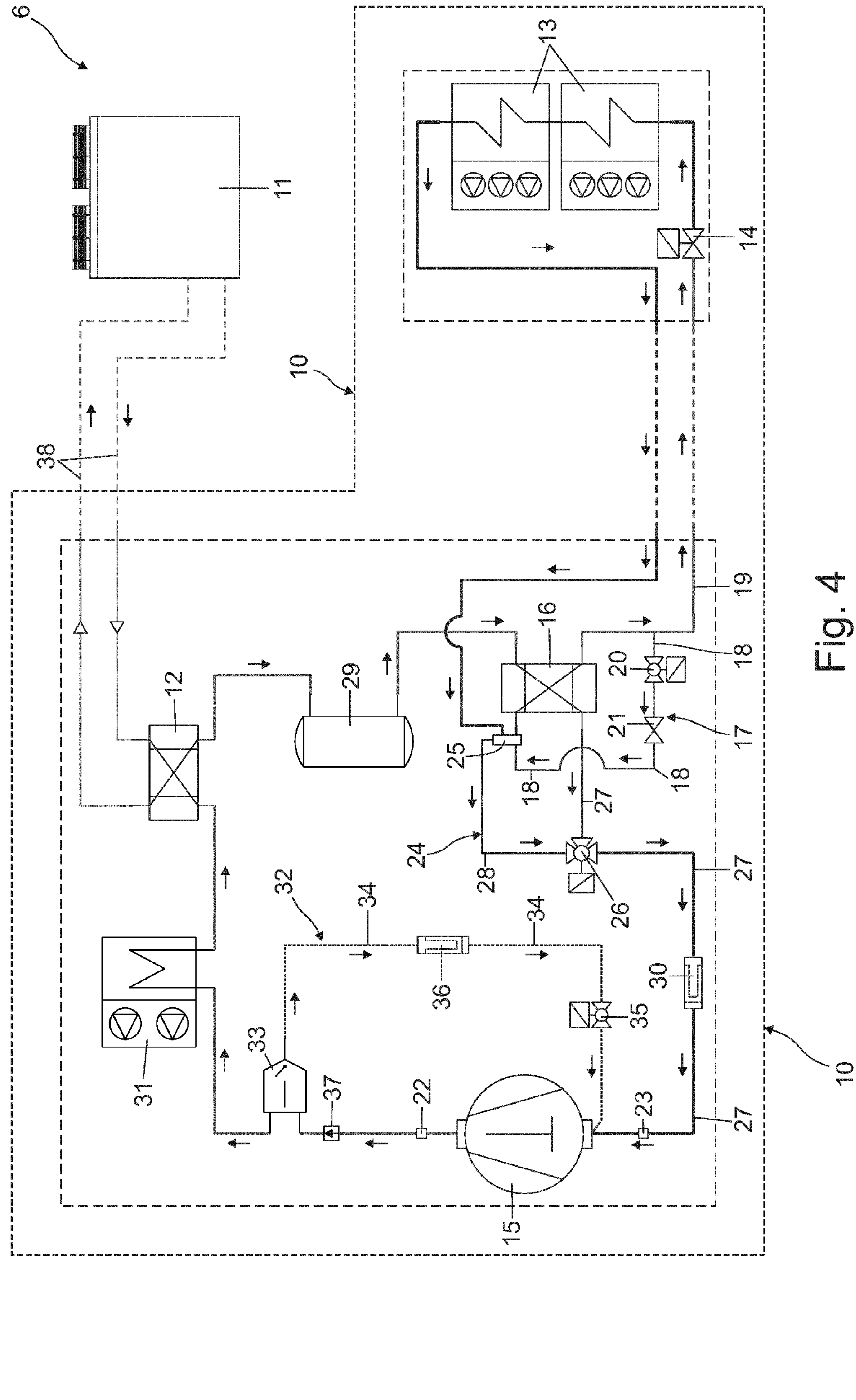
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Fig. 4

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Application Number
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Application Number
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