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(54) Combined refrigerating and vacuum-generating apparatus

(57) A combined refrigerating and vacuum-generating apparatus is described, comprising:

- a refrigerating circuit comprising a compressor (1) for compressing a refrigerating fluid, a condenser (2) for condensing the refrigerating fluid coming from the compressor (1), an expansion unit (5) for causing a pressure drop in the refrigerating fluid, and at least one evaporator (6) for the evaporation of the refrigerating fluid, said refrigerating circuit it being divided into a high-pressure side (AP) and a low-pressure side (BP);
- means (10, 11, 12) for generating vacuum inside a container (13).

The invention is characterized in that said vacuum-generating means (10, 11, 12) are connected to the low-pressure side (BP) of the refrigerating circuit, so as to exploit the pressure differential being present within said refrigerating circuit in order to generate vacuum inside said container (13).

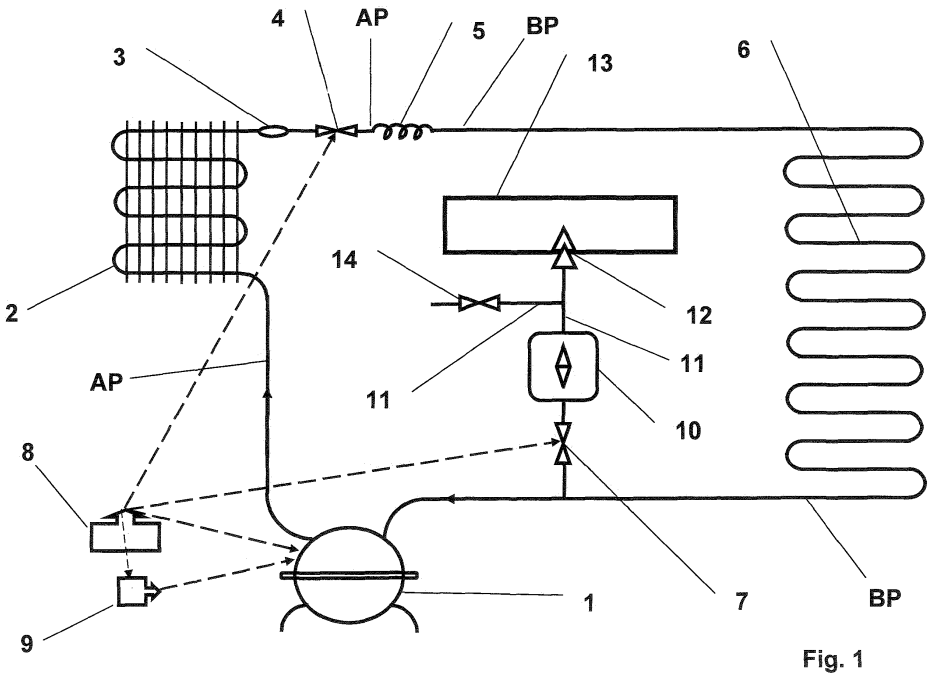

Fig. 1

EP 1 640 678 A2

Description

[0001] The present invention relates to a combined refrigerating and vacuum-generating apparatus according to the preamble of claim 1.

[0002] Notoriously, the most widespread method for preserving food consists in placing it into refrigerating apparatuses, such as, for example, refrigerators, freezers or similar apparatuses, because at low temperatures biological activities are reduced and food alteration processes are slowed down.

[0003] The cooling of said refrigerating apparatuses, and consequently of the food contained therein, occurs in a known way; in fact, said apparatuses are fitted with a refrigerating circuit comprising a compressor, a condenser, an expansion unit and an evaporator.

[0004] The task of the compressor is to compress a refrigerating fluid, typically R134a or R600a, which thus reaches a high pressure, and send it in gaseous state to the condenser, wherein the refrigerating fluid condenses and becomes a high-pressure liquid.

[0005] Subsequently, the high-pressure refrigerating fluid flows through an expansion unit, which is a component installed between the condenser and the evaporator assembly of the refrigerating circuit, having the function of causing a sharp pressure drop in the refrigerating fluid. The expansion unit therefore acts as a pressure differential; the presence of a pressure differential in a refrigerating circuit is very important, because it produces a change of the refrigerating fluid boiling point. Without this pressure change, the refrigerating circuit would just be a simple container of refrigerating fluid, as said refrigerating fluid would not reduce its temperature drastically, reaching some tens of °C below zero, and therefore no refrigeration would take place.

[0006] The refrigerating fluid exiting the expansion unit, which generally consists of a small tube called "capillary", is then sent to the evaporator, which runs within the walls of the refrigerating apparatus in order to absorb heat from within the cell to be cooled. Having absorbed heat, the refrigerating fluid evaporates and returns to the gaseous state; this allows to obtain the refrigerating process within the refrigerating apparatus.

[0007] The refrigerating fluid, being in gaseous state, is subsequently aspirated by the compressor, so as to repeat the refrigeration cycle.

[0008] Another food preservation technique is also known, which consists in placing the food in special containers wherein vacuum is generated in order to reduce the chemical processes and biological activities due to lack of oxygen, thereby slowing down food deterioration. The vacuum technique allows to achieve good preservation results, on condition that the optimum vacuum level is provided.

[0009] The generation of vacuum inside food containers takes place in a known way, in particular by using a vacuum- generating circuit comprising a motor, a pump and a duct being connected to the food container. When the motor is turned on, the vacuum pump performs a suction action which, through the connection duct, sucks the air being present inside the container, thus generating vacuum therein.

[0010] In the refrigerating apparatuses known in the art, the above food preservation techniques have sometimes been combined together, aiming at obtaining a synergic result in order to extend food preservation times.

[0011] In fact, several known refrigerating apparatuses, in particular refrigerators, freezers or similar apparatuses, are fitted with a refrigerating circuit for refrigeration plus a circuit for generating vacuum inside food containers.

[0012] According to the present state of the art, the refrigerating circuit and the vacuum-generating circuit are separate. Therefore, said refrigerating apparatus have some drawbacks, like the large number of components making up the refrigerating circuit and the vacuum-generating circuit; inevitably, such a complexity translates into higher costs.

[0013] Moreover, the refrigerating apparatuses known in the art employ a vacuum pump connected to its own motor being separated from the refrigerating circuit and supplied by the electric line as well.

[0014] The present invention aims at eliminating the above-mentioned drawbacks and at providing a combined refrigerating and vacuum-generating apparatus, in particular a refrigerator or a freezer, having an improved and different construction with respect to known solutions.

[0015] Within such a scope, the main object of the present invention is to provide a combined refrigerating and vacuum-generating apparatus being fitted with economical and effective means for generating vacuum inside food containers.

[0016] A further object of the present invention is to provide a combined refrigerating and vacuum-generating apparatus which, at the price of a reasonable electric energy consumption, offers very good performance.

[0017] In order to achieve such objects, the present invention provides a combined refrigerating and vacuum-generating apparatus incorporating the features of the annexed claims.

[0018] Further objects, features and advantages of the present invention will become apparent from the following detailed description and annexed drawings, which are supplied by way of nonlimiting example, wherein:

- Fig. 1 shows a basic diagram of an apparatus according to the invention;
- Fig. 2 shows a schematic sectional view of a detail of the apparatus of Fig. 1.

[0019] Fig. 1 shows a basic diagram of a combined refrigerating and vacuum-generating apparatus according to the invention. Said diagram illustrates a refrigerating circuit of a refrigerating apparatus; said refrigerating circuit comprises a compressor 1, a condenser 2, an ex-

pansion unit 5 and an evaporator 6.

[0020] The compressor 1 is powered through an electric line, which can be closed through a switch (not shown in the illustrations, being it of a known type), and is controlled by a thermostat 9, which controls the temperature inside the refrigerating apparatus.

[0021] The condenser 2 may be of any known type being usable in household refrigerating apparatuses, in particular it may be an air-cooled, static, finned-battery and/or ventilated by means of a fan not shown in the illustration.

[0022] In the embodiment of Fig. 1, the expansion unit 5 consists of a capillary, i.e. a thin duct being some meters long; said capillary may nonetheless be replaced with any other type of expansion unit known in the art.

[0023] The expansion unit 5 allows to obtain a sharp pressure drop in the refrigerating fluid being present in the refrigerating circuit and to dose the refrigerating fluid entering the evaporator 6; it can be easily understood that, if the refrigerating apparatus has more than one refrigerating compartment, the refrigerating circuit will comprise a plurality of evaporators 6 according to a known method.

[0024] The refrigerating circuit also comprises a filter 3, in particular being located upstream the expansion unit 5, adapted to trap any impurity being present in the refrigerating circuit, so as to prevent the expansion unit 5 from being clogged.

[0025] As known, the refrigerating circuit is divided into a high-pressure side AP, i.e. a set of components wherein the refrigerating fluid is at high pressure, and a low-pressure side BP, i.e. a set of components wherein the refrigerating fluid is at low pressure; the high-pressure side AP begins at the outlet of the compressor 1, comprises the condenser 2 and reaches the inlet of the expansion unit 5. The low-pressure side BP begins at the outlet of the expansion unit 5, comprises the evaporator 6 and reaches the inlet of the compressor 1.

[0026] In the embodiment of Fig. 1, the refrigerating circuit also comprises a first valve 4, being located on the high-pressure side AP of the refrigerating circuit, in particular downstream the condenser 2, and a second valve 7, being located on the low-pressure side BP of the refrigerating circuit, in particular downstream the evaporator 6.

[0027] The first valve 4 allows to close the refrigerating circuit, thereby preventing the refrigerating fluid from flowing from the high-pressure side AP to the low-pressure side BP.

[0028] The second valve 7 allows to connect vacuum-generating means to the low-pressure side BP of the refrigerating circuit; in the representation of Fig. 1, the vacuum-generating means comprise a pump 10, being preferably a reciprocating pump, which may be connected to a container 13 through a duct 11 and a connection element 12.

[0029] As known, current refrigerating apparatuses comprise an electronic control system adapted to control the operation of the household appliance and of its various parts, which may comprise a control panel which the user can operate.

[0030] The compressor 1, the first valve 4, the second valve 7 and the thermostat 9 are controlled by an electronic control system 8 of the refrigerating apparatus, in the example of Fig. 1 said electronic control system 8 consisting of an electronic control board; moreover, said electronic control system 8 is capable of controlling the compressor 1 independently of the state of the thermostat 9.

[0031] The container 13 consists of a hermetically sealed vessel adapted to be housed in a compartment of the refrigerating apparatus; said container 13 is also fitted with an opening adapted to be closed by a valve, in particular a mechanic valve (not shown in the illustrations), which allows to keep the vacuum inside the container 13.

[0032] The connection element 12 may consist of, for example, a plastic spout; in any case, the connection element 12 is made in such a way as to connect the container 13 to the duct 11, and is located in a compartment of the refrigerating apparatus, preferably in an inner wall of said apparatus.

[0033] The connection element 12 and the container 13 may also be provided with sealing means, e.g. gaskets.

[0034] The duct 11 comprises a normally closed valve 14; when said valve 14 is opened, e.g. by operating a push-button (not shown in the illustrations) of the refrigerating apparatus, air enters the duct 11 in order to re-establish the atmospheric pressure within the duct 11, thereby facilitating the removal of the container 13 from the connection element 12.

[0035] Fig. 2 shows a schematic section of the pump 10. Said pump 10 has a body 15, in particular having a cylindrical shape, it being hermetically divided on the inside into a first cavity A and a second cavity B by a movable element 16, in particular a bellows; the volumes and pressures of the first cavity A and of the second cavity B vary depending on the deformation of the movable element 16.

[0036] The first cavity A is connected to the duct 11 through a valve 17 and to the atmosphere through a valve 18; the second cavity B is connected to the low-pressure side BP of the refrigerating circuit CR through the valve 7. The valves 17 and 18 are mechanic valves opening and closing depending on the pressure being present within the first cavity A. In particular, the valve 17 opens when in the first cavity A there is a pressure which is lower than that being present within the duct 11, and closes when in the first cavity A there is a pressure being higher than that being present within the duct 11; vice versa, the valve 18 opens when in the first cavity A there is a pressure being higher that the atmospheric pressure, and closes when in the first cavity A there is a pressure being lower that the atmospheric pressure.

[0037] The combined refrigerating and vacuum-gen-

erating apparatus according to the present invention, capable of generating vacuum inside the food container 13, operates as follows.

[0038] The refrigerating circuit of the refrigerating apparatus according to the present invention can operate in two modes; a first refrigerating mode and a second vacuum-generating mode.

[0039] When the refrigerating circuit of the refrigerating apparatus is operating in the refrigerating mode, the compressor 1 aspirates the refrigerating fluid from the low-pressure side BP and delivers it, at high pressure, to the high-pressure side AP and into the condenser 2, wherein said refrigerating fluid condenses and cools down. After having passed through the filter 3 and the first valve 4, the refrigerating fluid flows through the expansion unit 5 and enters at low pressure the low-pressure side BP of the refrigerating circuit.

[0040] Then the refrigerating fluid flows through the evaporator 6, which consists of a system of pipes being arranged as a coil running mostly within the walls of the refrigerating appliance and then returning to the compressor 1; when it flows through the evaporator 6, the refrigerating fluid evaporates, thereby cooling the compartments of the refrigerating apparatus.

[0041] Along this path of the refrigerating fluid, the electronic control system 8 keeps the first valve 4 open and the second valve 7 closed; in this situation, therefore, the vacuum-generating means, in particular the pump 10, are not connected to the low-pressure side BP of the refrigerating circuit CR, and the refrigerating apparatus performs its usual refrigeration cycles for food cooling.

[0042] If a user wants to generate vacuum inside the container 13, he/she connects the container 13 to the connection element 12 and then operates a control, e.g. a push-button (not shown in the illustrations), which allows the electronic control system 8 to generate signals adapted:

- disconnect the thermostat 9 from the refrigerating circuit, so that said thermostat 9 cannot cause the activation and/or deactivation of the compressor 1;
- close the first valve 4, so that the refrigerating fluid cannot flow to the low-pressure side BP through the expansion unit 5;
- open the second valve 7, so as to connect the vacuum-generating means, in particular the pump 10, to the low-pressure side BP of the refrigerating circuit;
- activate the compressor 1, which sucks the refrigerating fluid from the low-pressure side BP and delivers it to the high-pressure side AP and into the condenser 2;

[0043] Following the activation of the compressor 1, the pressure in the low-pressure side BP drops; since the second valve 7 is open, the movable element 16 of the pump 10 moves downward. In such a situation, the volume of the first cavity A increases, whereas the pressure within said first cavity A decreases. This pressure reduction in the first cavity A causes the valve 17 to open and the valve 18 to close; since the valve 17 connects the first cavity A to the duct 11, and since the container 13 is connected to the connection element 12, air is aspirated from the container 13 and vacuum is generated therein.

[0044] When the movable element 16 has reached the maximum possible contraction, the electronic control system 8 generates signals adapted to:

- deactivate the compressor 1;
- open the first valve 4, so that the refrigerating fluid can, due to the pressure differential being present between the high-pressure side AP and the low-pressure side BP, flow through the expansion unit 5 and to the low-pressure side BP.

[0045] Since the second valve 7 is still open, the refrigerating fluid flow to the low-pressure side BP causes a pressure increase both in said low-pressure side BP and in the second cavity B of the pump 10.

[0046] Once the refrigerating fluid flowed to the low-pressure side has determined a pressure increase in the second cavity B, the electronic control system 8 generates signals adapted to:

- close the valve 7, so as to disconnect the pump 10 from the low-pressure side BP of the refrigerating circuit;
- connect the thermostat 9 to the refrigerating circuit, so that it can cause the activation and/or deactivation of the compressor 1 and the refrigerating apparatus can operate in the refrigerating mode again.

[0047] The pressure increase in the second cavity B causes the expansion of the movable element 16 and an increase of the volume of said second cavity B; consequently, the volume of the first cavity A decreases and the pressure in said first cavity A increases.

[0048] This pressure increase in the first cavity A causes the valve 17 to close and the valve 18 to open, thereby connecting the first cavity A to the atmosphere and allowing the flexible element 16 to return to its original configuration, indicated in Fig. 2 with a dashed line.

[0049] After having flowed through the expansion unit 5 and to the low-pressure side BP, the refrigerating fluid enters the evaporator 6 and generates a refrigerating apparatus cooling process, even if the compressor 1 is off; this allows to compensate the electric energy used for activating the compressor 1 for the purpose of generating vacuum inside the container 13.

[0050] Since vacuum has been generated in the duct 11 and inside the container 13, in order to be able to effortlessly remove the container 13 from the connection element 12, it is sufficient to cause the valve 14 to open, so as to allow air to flow into the duct 11, thereby depressurizing it; at this point it is possible to generate vacuum

inside a new container 13 by connecting it to the vacuum-generating means through the connection element 12 and by starting, through the electronic control system 8, a new vacuum generation cycle.

[0051] The movable element 16 according to the present invention may have a structure being similar to that employed in mechanic thermostats, i.e. a helical element being covered with a metal sheath. The dimensions of the pump 10 and of the movable element 16 may vary, in particular depending on the structure and/or the compartments of the refrigerating apparatus, e.g. to avoid taking up too much room inside the refrigerating apparatus. It is likely that, if the pump 10 and the movable element 16 are small, a single activation of the movable element 16 is not enough to generate the vacuum degree desired by the user inside the container 13; in these cases, it will however suffice to repeat the vacuum generation cycle inside the container 13 several times, until the vacuum degree inside the container 13 is as required by the user.

[0052] The operation of the refrigerating apparatus being the object of the present invention may therefore be schematized from the combined refrigeration and vacuum generation method by using a refrigerating apparatus comprising a refrigerating circuit it being divided into a high-pressure side and a low-pressure side, and means for generating vacuum inside a container, being coupled to the low-pressure side of the refrigerating circuit, wherein said refrigerating circuit performs the usual refrigeration cycles for cooling the refrigerating apparatus, with at least one cycle for generating vacuum in a container being performed in between.

[0053] If said vacuum-generating means are small, the refrigerating circuit may performs several consecutive vacuum generation cycles in order to generate vacuum inside the same container.

[0054] The features of the present invention, as well as its advantages, are apparent from the above description.

[0055] In particular, the connection of the vacuum-generating means to the low-pressure side of the refrigerating circuit allows to exploit the pressure differential being present within said refrigerating circuit in order to generate vacuum inside the container, in that the pump utilizes the cyclic pressure variations of the refrigerating fluid within the refrigerating circuit.

[0056] A further advantage of the present invention is represented by the use of the compressor of the refrigerating circuit not only for circulating the refrigerating fluid within the refrigerating circuit, but also for generating vacuum inside the container; this inevitably translates into a considerable energy saving, also taking into account that the cooling phase next to the phase for generating vacuum inside the container takes place with the compressor being turned off, i.e. without said compressor drawing electric energy.

[0057] A further advantage of the present invention is to provide a combined refrigerating and vacuum-generating apparatus fitted with vacuum-generating means which do not require any substantial changes to a typical refrigerating apparatus.

[0058] A further advantage of the apparatus according to the present invention is that the number of components making up the refrigerating circuit and the vacuum-generating means is considerably lower than required by the refrigerating devices of the prior art; the remarkable advantages offered by this solution are therefore apparent as concerns both the costs and the reliability of the entire apparatus.

[0059] It is clear that many other variations and applications of the refrigerating apparatus described herein by way of example are possible for those skilled in the art, as well as that in the practical realization of the invention the components may have shapes and dimensions being different from those described or be replaced with other technically equivalent elements.

[0060] Among the various possible modifications, the pump valves may be directly controllable by the electronic control system of the refrigerating apparatus. This variant would allow to further improve the operation of the combined refrigerating and vacuum-generating apparatus being the object of the present invention, as well as to fully exploit the potentiality of said electronic control system.

[0061] It can therefore be easily understood that the present invention is not limited to the above-described device, but may be subject to many modifications, improvements or replacements of equivalent parts and elements without departing from the novelty spirit of the inventive idea, as clearly specified in the following claims.

Claims

1. Combined refrigerating and vacuum-generating apparatus, comprising:

- a refrigerating circuit preferably comprising a compressor (1) for compressing a refrigerating fluid, a condenser (2) for condensing the refrigerating fluid coming from the compressor (1), an expansion unit (5) for causing a pressure drop in the refrigerating fluid, and at least one evaporator (6) for the evaporation of the refrigerating fluid, said refrigerating circuit it being divided into a high-pressure side (AP) and a low-pressure side (BP);
- means (10, 11, 12) for generating vacuum inside a container (13);

characterized in that

said vacuum-generating means (10, 11, 12) are connected to the low-pressure side (BP) of the refrigerating circuit, so as to exploit the pressure differential being present within said refrigerating circuit in order to generate vacuum inside said container (13).

2. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said vacuum-generating means (10, 11, 12) comprise a pump (10), being preferably a reciprocating pump, which utilizes the cyclic pressure variations of the refrigerating fluid being present within the refrigerating circuit.

3. Combined refrigerating and vacuum-generating apparatus according to the previous claim, **characterized in that** said pump (10) has a body (15) it being internally divided into a first cavity (A) and a second cavity (B) by a movable element (16).

4. Combined refrigerating and vacuum-generating apparatus according to the previous claim, **characterized in that** said movable element (16) comprises a helical element being covered with a metal sheath.

5. Combined refrigerating and vacuum-generating apparatus according to claim 3, **characterized in that** the volumes and pressures within said first cavity (A) and said second cavity (B) vary depending on the deformation of said movable element (16).

6. Combined refrigerating and vacuum-generating apparatus according to claim 2, **characterized in that** said vacuum-generating means (10, 11, 12) comprise a duct (11) and a connection element (12) which allow to connect said pump (10) to said container (13).

7. Combined refrigerating and vacuum-generating apparatus according to claims 3 and 6, **characterized in that** said first cavity (A) is connected to said duct (11) through a valve (17).

8. Combined refrigerating and vacuum-generating apparatus according to claim 3, **characterized in that** said first cavity (A) is connected to the atmosphere through a valve (18).

9. Combined refrigerating and vacuum-generating apparatus according to claims 7 and 8, **characterized in that** said valves (17, 18) are mechanic valves opening and closing depending on the pressure being present within said first cavity (A).

10. Combined refrigerating and vacuum-generating apparatus according to claims 7 and 8, **characterized in that** it comprises an electronic control system (8) and **in that** said valves (17, 18) are controlled by said electronic control system (8).

11. Combined refrigerating and vacuum-generating apparatus according to claim 6, **characterized in that** said connection element (12) is located in a compartment of the refrigerating apparatus, preferably in an inner wall of said apparatus.

12. Combined refrigerating and vacuum-generating apparatus according to claim 6, **characterized in that** said duct (11) comprises a valve (14), in particular a normally closed valve, which allows to let air into said duct (11).

13. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said refrigerating circuit can operate in two modes, in particular a first refrigerating mode and a second vacuum-generating mode.

14. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said refrigerating circuit comprises a first valve (4) being located on the high-pressure side (AP), in particular downstream said condenser (2), which allows to close the refrigerating circuit, thereby preventing the refrigerating fluid from flowing from the high-pressure side (AP) to the low-pressure side (BP).

15. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said refrigerating circuit comprises a second valve (7) being located on the low-pressure side (BP), in particular downstream the evaporator (6), which allows to connect said vacuum-generating means (10, 11, 12) to the low-pressure side (BP) of the refrigerating circuit.

16. Combined refrigerating and vacuum-generating apparatus according to claims 14 and 15, **characterized in that** it comprises an electronic control system (8) and **in that** said first valve (4) and/or said second valve (7) are controlled by said electronic control system (8).

17. Combined refrigerating and vacuum-generating apparatus according to claims 3 and 15, **characterized in that** said second cavity (B) is connected to the low-pressure side (BP) of the refrigerating circuit through said second valve (7).

18. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said compressor (1) is driven by a thermostat (9), which controls the temperature inside said refrigerating apparatus.

19. Combined refrigerating and vacuum-generating apparatus according to the previous claim, **characterized in that** it comprises an electronic control system (8) able to control said compressor

(1) independently of the state of said thermostat (9).

20. Combined refrigerating and vacuum-generating apparatus according to claim 1, **characterized in that** said refrigerating circuit comprises a filter (3), in particular being located upstream the expansion unit (5), adapted to for trap any impurity being present in the refrigerating circuit, so as to prevent said expansion unit (5) from being clogged.

21. Method for combined refrigeration and vacuum generation through the use of a refrigerating apparatus comprising:

- a refrigerating circuit it being divided into a high-pressure side (AP) and a low-pressure side (BP);
- means (10, 11, 12) for generating vacuum inside a container (13), being coupled to the low-pressure side (BP) of the refrigerating circuit;

wherein said refrigerating circuit performs the usual refrigeration cycles for cooling the refrigerating apparatus, with at least one cycle for generating vacuum in said container (13) being performed in between.

22. Method for combined refrigeration and vacuum generation according to the previous claim, **characterized in that** said refrigerating circuit performs several consecutive vacuum generating cycles in order to generate vacuum inside the same container (13).

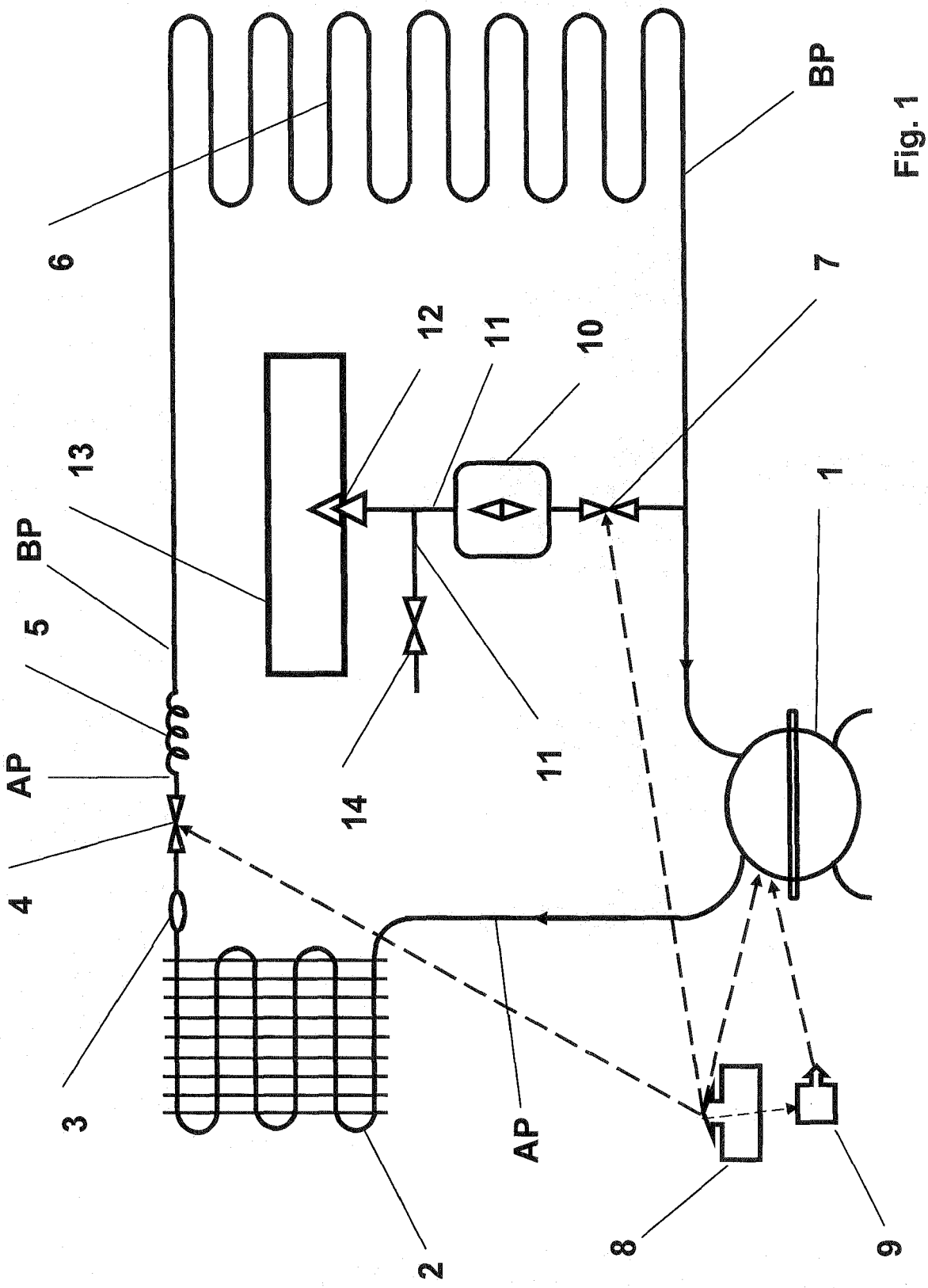

Fig. 1

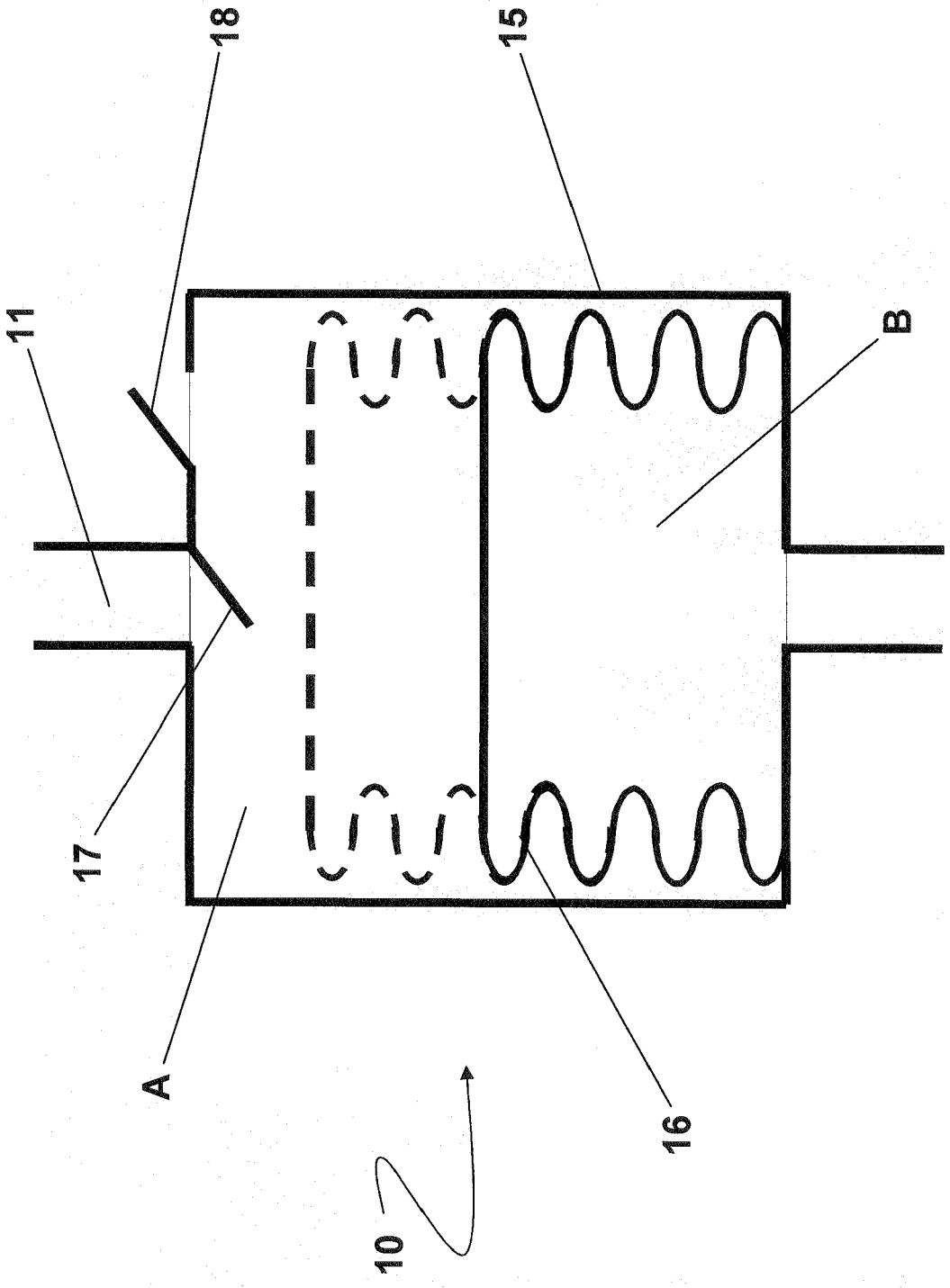

Fig. 2