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(54) **Free cooling chiller**

(57) Free cooling chiller (1) comprising a primary circuit (2) of a refrigerating plant, provided with an evaporator (6), a condenser group (5) and a compressor (4) and able to perform heat exchange by means of the evaporator (6) with a secondary circuit (3) for transferring refrigerating power to user appliances. The secondary circuit (3) is provided with a return line (10) intercepted by

a free cooling group (13) and a circuit for bypassing the free cooling group. The chiller (1) is provided with a support structure (14) defining a containing compartment (16) acted on by an air flow produced by a ventilation unit (15). The condenser group (5) and the free cooling group (13), which are intercepted by corresponding gate valves (17,18), communicate via separate sections with the compartment (16).

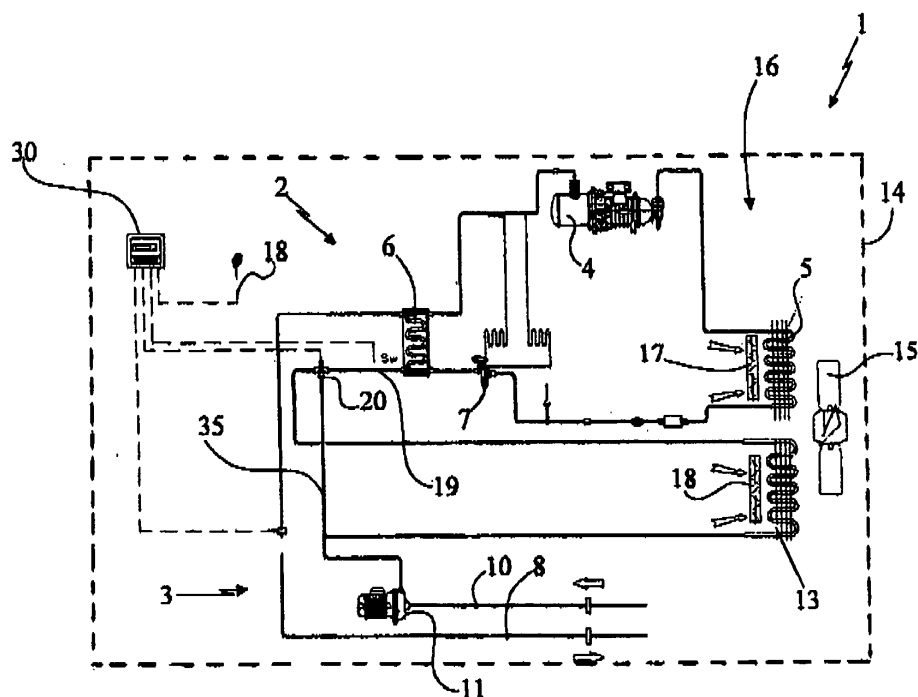


Fig. 1

Description

Field of application

[0001] The present invention relates to a free cooling chiller.

[0002] The chiller according to the present invention is classifiable generally within the sector of air conditioning plants, in particular of the "free cooling" type as commonly referred to in the technical jargon of the sector.

[0003] More specifically it is intended to be used advantageously in those applications where it is possible to recover refrigerating power from the low-temperature external air.

Background art

[0004] The growing need to save energy has given a considerable boost to the development of free cooling chillers with the aim of reducing the operating costs in working conditions where there are particularly low external air temperatures, for example less than 10°C for longer or shorter periods during the year.

[0005] Free cooling chillers make use of the low temperature of the external air in order to cool the liquid to be sent to the user plant and are generally used where refrigerating power also at low temperatures is required.

[0006] Free cooling chillers are chillers operating with water (or preferably an anti-free mixture) and provided with additional groups (referred to below as free cooling groups) for heat exchange of the water/air type able to recover refrigerating power supplied by the external air. With these chillers it is possible to supplement the refrigerating power normally supplied by the compressors or even replace it entirely when there are suitable external air conditions.

[0007] In other words, they are able to cool the carrier fluid (preferably an anti-freeze fluid) by means of a vapour compression refrigerating cycle and/or, if permitted by the external air temperature conditions, by means of direct exchange between the air and the fluid itself.

[0008] Conventionally, a free cooling chiller comprises a primary circuit or refrigerating circuit and a secondary circuit or user circuit. The primary circuit is formed by a compressor, a condenser, a thermostatic expansion valve and an evaporator.

[0009] The secondary circuit comprises a line for delivery of the liquid to the user appliances, which is arranged at the evaporator outlet, and a liquid return line from the user appliances, connected to the evaporator inlet. The latter line is provided with a pump for circulating the liquid in the secondary circuit.

[0010] The secondary circuit comprises, moreover, a free cooling group connected along the return line by means of a servo-controlled three-way valve to which a bypass line for switching in or excluding the free cooling group is also connected.

[0011] A logic control unit is provided for performing

activation of the valve in order to exploit fully the refrigerating power associated with the external air, thus minimizing the energy used by the compression system.

[0012] The free cooling group is placed in series with the evaporator of the primary circuit and is by-passed when its efficiency falls below a convenience threshold following a change in the external air conditions. Instead, where permitted by the climatic conditions, the free cooling group allows cooling of the secondary fluid by means of the external air, reducing the use of the compressors.

[0013] The control unit decides with regard to the operating conditions, taking into account the external air temperature and the return temperature of the liquid in the secondary circuit, detected by means of probes.

[0014] Therefore, the chillers of the type described above differ from more conventional chillers owing to the presence of the free cooling group which acts as an air/water exchanger situated upstream of the evaporator of the primary circuit.

[0015] Advantageously, the free cooling group exploits the low temperature of the air in order to cool the return water of the plant before sending it to the evaporator.

[0016] Hitherto substantially two types of free cooling chillers are known.

[0017] A first type, which is schematically shown in Figure A and described for example in the patent US 5,970,729, envisages arranging, in separate positions, the condenser group and the free cooling group and each of the two groups is provided with its own fan unit.

[0018] This type of chiller ensures the complete operating autonomy of the free cooling group from operation of the refrigerating primary circuit.

[0019] In accordance with this type of free cooling operation, control of the condensation, or control such that the output pressure of the condenser does not fall below minimum values required by the compressor, is obtained by means of adjustment of the speed of the fan unit of the condenser group. By varying the speed of the fan the heat exchange conditions in the condenser, and therefore the temperature and pressure, are varied. As is known, the compressor requires, for correct operation, a pressure differential between delivery and intake higher than a minimum value.

[0020] The type of chiller described above has the drawback that it is particularly bulky and excessively complex in that it requires the use of two separate ventilation units.

[0021] A second type of chiller, which is shown schematically in Figure B and described for example in the patent US 4,932,221, envisages arranging the free cooling and condenser groups opposite each other so as to make use of the same air flow produced by a single ventilation unit.

[0022] This type of chiller allows the dimensions to be kept small and the number of fans to be reduced. In this case, control of the condensation pressure, which is necessary during simultaneous operation of the two groups, is performed by means of throttling of the condenser

group or expansion of the group.

[0023] This second type of chiller has the drawback that it is very complex and difficult to produce.

[0024] A further drawback consists in the high losses of head due to the installation, in series, of the two groups within the same air flow.

[0025] Another drawback consists in the fact that adjustment of the speed of the ventilation unit produces effects on both the groups, which could have different requirements. For example, when there is particularly cold external air, excessive cooling of the condenser could result in an undesirable and excessive lowering of the pressure upstream of the compressor. Moreover, in order to exploit fully the refrigerating power of the air, it would instead be necessary to keep the ventilation unit at maximum speed in order to create the maximum air flow on the free cooling group.

[0026] Therefore, adjustment of operation of the ventilation unit on the condenser necessarily results in a reduced efficiency of the chiller or reduced exploitation of the free cooling.

[0027] Differently, throttling of the primary circuit instead of adjustment of the ventilation unit in order to control the condensation pressure results, as mentioned, in considerable constructional complication of the primary circuit with the addition of numerous components in the primary circuit.

Disclosure of the invention

[0028] In this situation, therefore, the object of the present invention is to overcome the drawbacks of the prior art mentioned above by providing a free cooling chiller which is not voluminous and at the same time is constructionally simple to produce and operationally entirely reliable.

[0029] A further object of the present invention is provide a chiller which is able to best exploit fully the free cooling group and recover efficiently the refrigerating power of the external air.

Brief description of the drawings

[0030] The technical features of the invention, in accordance with the abovementioned objects, may be clearly determined from the contents of the accompanying claims and the advantages thereof will emerge more clearly from the detailed description which follows, provided with reference to the accompanying drawing which shows a purely exemplary and non-limiting embodiment in which:

- Figure 1 shows a diagram of the free cooling chiller according to the present invention.

Detailed description

[0031] With reference to the accompanying figure, the

chiller according to the invention has been denoted in its entirety by 1. It is able to satisfy all the cooling requirements by making use, as will be clarified below, of both the refrigerating power of the compressor and the external air temperature conditions.

[0032] The chiller is of the free cooling type, namely is intended to be used where it is considered possible to exploit freely the low external temperature of the air.

[0033] Typically, this chiller may therefore be used advantageously for cooling service rooms which are heated by computers, telephone exchanges, or the like.

[0034] Alternatively, it may also be used in spacious premises such as cinemas or supermarkets, where it is required to keep the environment air-conditioned (for example owing to the presence of a large number of people) also where there are low external temperatures.

[0035] With reference to the diagram according to Figure 1, the chiller 1 comprises a primary circuit or refrigerating circuit 2 and a secondary circuit or user circuit 3. The primary circuit 2 is formed, for example, in a manner conventional per se, by a compressor 4, by a condenser group 5, by an evaporator 6 and by a thermostatic expansion valve 7 able to cause throttling of the refrigerating fluid.

[0036] The secondary circuit 3 comprises a line 8 for delivery, to the user appliances, of a cooling carrier fluid, generally consisting of an anti-freeze mixture, which line is connected to the outlet of the evaporator 6, and a return line 10, which is connected to the inlet of the evaporator 6. The latter line 10 is provided with a pump 11 for circulating the liquid inside the secondary circuit 3.

[0037] The return line 10 of the secondary circuit 3 is also intercepted by a free cooling group 13 which is therefore arranged in series with the evaporator 6. The evaporator and the free cooling group 13 have, arranged between them, a servo-controlled three-way valve 20 to which a bypass line 35 also leads, the latter being connected at the other end immediately upstream of the free cooling group 13.

[0038] According to the idea forming the basis of the present invention, the chiller 1 comprises a support structure 14 (indicated by broken lines in the Figure) which preferably has a box-shaped form and is formed by metal panels and on which a ventilation unit 15 is mounted, said unit causing the suction of an air flow from a containing compartment 16 inside the support structure 14. The condenser group 5 intercepted by a first motorized gate valve 17 and the free cooling group 13 intercepted by a second motorized gate valve 18 communicate with this compartment 16 via separate sections.

[0039] The two groups are placed in parallel such the air flow is selectively drawn in by one or other section depending on opening of the gate valves 16 and 17 positioned so as to intercept them.

[0040] A logic control unit 30 is provided for performing activation of the three-way valve 20 in order to exploit fully the refrigerating power associated with the external air, thus minimizing the power used by the compression

system.

[0041] The free cooling group 13 is positioned in series with the evaporator 6 of the primary circuit 2 and is bypassed when its efficiency falls below a convenience threshold following a change in the external air conditions. On the other hand, where permitted by the climatic conditions, the free cooling group 13 allows cooling of the carrier fluid of the secondary circuit 3 by means of the external air, reducing the use of the compressor 4.

[0042] In order to select the optimum operating mode, the logic control unit 30 is connected to a first probe 18 able to detect the temperature of the external air and to a second probe 19 able to detect the temperature of the fluid of the return line.

[0043] From an operational point of view, the control unit 30 controls the motor of the three-way valve 20 so as to select the flow of the carrier fluid through the bypass circuit 35 or through the free cooling group 13 in accordance with a programmed operating logic.

[0044] Advantageously, the ventilation unit 15 consists of an axial fan with the motor directly connected to the fan shaft and controlled electronically with a phase cutting system which allows the speed of the fan to be varied.

[0045] During operation as a normal chiller, namely with the free cooling group 13 bypassed, the speed of the fan 15 is dependent upon the pressure of the condenser group 5. Therefore, when the condensation pressure falls or rises, the speed of the fan correspondingly falls or rises so as to maintain a sufficient pressure head on the compressor 4.

[0046] When the free cooling mode is activated, since the external conditions permit it, the axial fan 15 is operated at the maximum nominal power and the system for adjusting the condensation pressure is switched to the first gate valve 17 which therefore opens or closes the air flow which passes through depending on whether the pressure of the condenser group 5 rises or falls.

[0047] Obviously, the pressure conditions of the condenser group 5 depend also on the refrigerating power requirement of the user appliances.

[0048] Alternatively, the first gate valve 17 has preferably an ON-OFF regulating system, remaining completely open during operation of the free cooling group 13 and remaining completely closed when the free cooling group 13 is bypassed.

[0049] In fact, when the free cooling group 13 is activated, it is obviously advantageous to convey over it the greatest possible amount of external fresh air so as to reduce the power used in the compressor 4.

[0050] Therefore, upon activation of free cooling mode, the second gate valve 18 is completely opened (using the ON/OFF logic), while the first gate valve 17 is opened in modulated manner as determined by the pressure of the condenser group 5.

[0051] Alternatively, in accordance with a different embodiment of the present invention, if the ventilation unit 15 consists of centrifugal fan, opening of the first gate valve 17 may be controlled as specified above or prefer-

ably may always be controlled by the pressure of the condenser group 5. In fact, the centrifugal fan 15 preferably must always operate at maximum speed for reasons of efficiency and because it does not have the motor directly connected to the fan shaft but driven via a belt.

[0052] Therefore, upon activation of free cooling mode, the flow of the fan 15 is increased and is however now also distributed over the free cooling group 13 such that the flow over the condenser group 5 may not vary greatly and may be adjusted with precision by means of adjustment of the first gate valve 17 directly controlled by the pressure of the condenser.

[0053] Advantageously, with the chiller 1 according to the present invention, it is possible to achieve a very compact configuration using a limited number of components for the refrigerating circuit. In particular, the condenser group 5 of the chiller 1 according to the invention remains substantially unchanged compared to a standard chiller without free cooling, with a considerable saving in terms of warehouse and production costs.

[0054] There may be many constructional arrangements of the gate valves 17 and 18 and of the groups 5 and 13 mounted on the support structure 14 of the chiller 1, provided that there always remains the common feature of communication with a single containing compartment 16 from which the ventilation unit 15 performs suction.

[0055] The invention therefore achieves the predefined objects.

[0056] Obviously, the invention may assume, in its practical embodiment, also forms and configurations different from that illustrated above, without thereby departing from the present scope of protection.

[0057] Moreover, all the details may be replaced by technically equivalent parts, and the dimensions, the forms and the materials used may be of any nature according to requirements.

Claims

1. Free cooling chiller comprising:

- a primary circuit of a refrigerating plant with refrigerating fluid, provided with at least one evaporator, at least one condenser group and at least one compressor;
- a secondary circuit with a carrier fluid, capable of heat exchange with the evaporator of said primary circuit so as to transfer refrigerating power from the evaporator to the user appliances, provided with a delivery line and a return line, which is intercepted by at least one free cooling group;
- a bypass circuit connected to said return line upstream and downstream of said free cooling group so as to connect or disconnect said free cooling group in series with said evaporator;

characterized in that it comprises a support structure defining a containing compartment acted on by an air flow produced by at least one ventilation unit, with which compartment the condenser group, intercepted by a first gate valve, and the free cooling group, intercepted by a second gate valve, communicate via separate sections. 5

2. Chiller according to Claim 1, **characterized in that** it comprises a logic control unit connected to at least one first probe for the temperature of the external air and to at least one second probe for the temperature of the fluid in the return line, said unit being able to control the flow of the carrier fluid through the bypass circuit or through the free cooling group in accordance with a programmed operating logic. 10 15
3. Chiller according to Claim 1, **characterized in that** at least one of said first and second gate valves is operated by a motor. 20
4. Chiller according to Claim 1, **characterized in that** opening of said first gate valve is controlled depending on the pressure of the condenser group during operation of the free cooling group. 25
5. Chiller according to Claim 1, **characterized in that** said ventilation unit is controlled by the pressure of the condenser group when the free cooling group is bypassed. 30
6. Chiller according to Claim 1, **characterized in that** said ventilation unit comprises an axial fan operating at a constant speed during operation of the free cooling group. 35
7. Chiller according to Claim 1, **characterized in that** said first gate valve has an ON/OFF regulating system which is open during operation of the free cooling group and closed when the free cooling group is bypassed. 40
8. Chiller according to Claim 1, **characterized in that** said ventilation unit is formed by a centrifugal fan and **in that** opening of said first gate valve is always controlled depending on the pressure of the condenser group. 45

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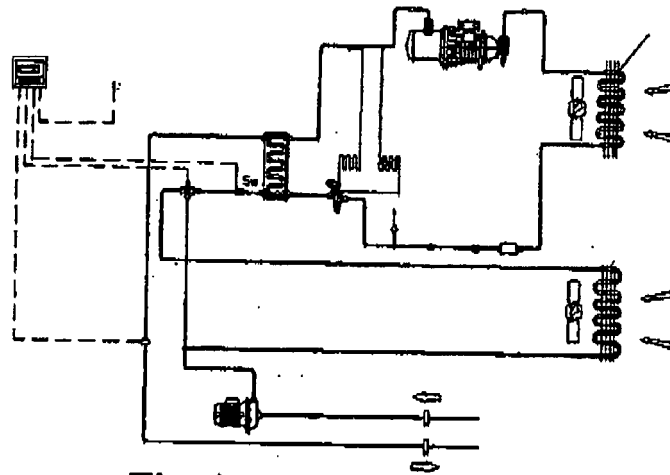


Fig. A

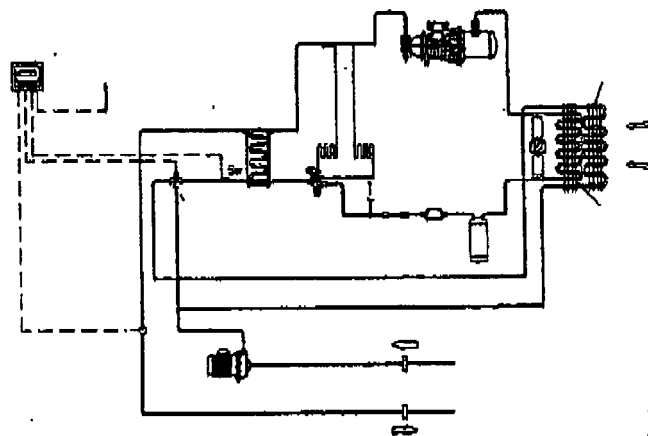


Fig. B

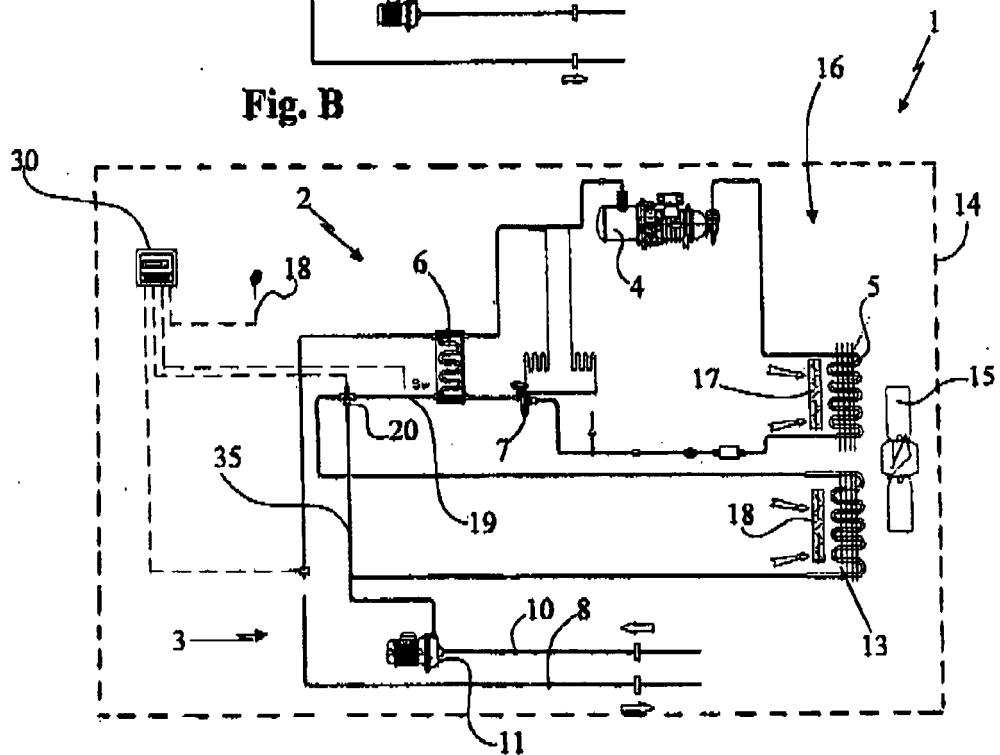


Fig. 1

REFERENCES CITED IN THE DESCRIPTION

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