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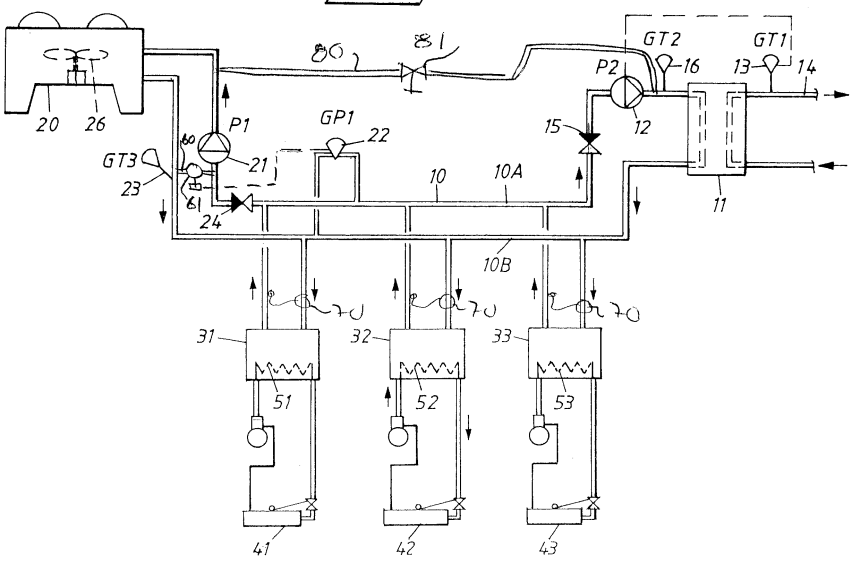
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(54) A refrigeration plant

(57) A refrigeration plant comprising a refrigerant circuit (10) including a first pump (12), a first heat consumer (11, 14), at least two secondary heat exchangers (31-33) which are connected in parallel across conducting parts (10a, 10b) of the circuit (10) said parts (10a, 10b) being connecting to the heat consumer (11) and functioning to cool a respective heat emitting unit (51-53, 51'-53') which is through-passed by refrigerant and which belongs to at least one refrigeration plant (41';41-43), such as a refrigerator or freezer. The pumps (12 21) are adapted to drive the refrigerant in mutually opposite directions such that the circuit will obtain a low pressure side (10a) and a high pressure side (10b). The plant also includes a pressure difference sensor (22) which detects the pressure difference between the low pressure side (10a) and the high pressure side (10b). The second pump (21) is adapted to deliver a generally constant flow of refrigerant. A shunt line (60) is established between the high pressure side (10b) and the low pressure side (10a) and contains a device (61) for controlling the flow of refrigerant through the shunt line (60), wherein the flow controlling device (61) is controlled by the pressure difference sensor so as to maintain a generally constant pressure difference between the high pressure side (10b) and the low pressure side (10a).

Fig.1



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Description

[0001] The invention relates to a plant of the kind defined in the preamble of the accompanying claim 1.

[0002] A plant of this kind is earlier known from EP-A-02445030.6. This earlier known plant comprises a refrigerant circuit that includes a first pump for driving refrigerant through a heat consumer, at least two secondary heat exchangers that are connected in parallel across circuit conducting portions that connect to the heat consumer, wherein the secondary heat exchangers are adapted to cool a respective heat emitting unit through which refrigerant flows and which is associated with at least one cooling/chilling plant such as a refrigerator or freezer. The refrigerant circuit includes a primary heat exchanger which functions to emit heat from the environmental surroundings, preferably to atmospheric air. The secondary heat exchangers are connected in the circuit, between the heat consumer and the primary heat exchanger. The primary heat exchanger includes a second pump which drives refrigerant in a pre-determined direction through the primary heat exchanger. The first pump is adapted to drive the refrigerant in a pre-determined direction through the heat consumer. The first pump and the second pump are adapted to drive the refrigerant in mutually opposite directions, such that the circuit on a low pressure side from which the pumps pump refrigerant and the circuit on a high pressure side to which the pumps pump refrigerant, a pressure difference sensor detects the pressure difference between the low pressure side and the high pressure side of the circuit, and wherein the first pump is controlled to satisfy the heat requirement of the heat consumer.

[0003] In the case of earlier known refrigeration plants, the pump of the primary heat exchanger is controlled by the pressure difference sensor, meaning that the flow of refrigerant passing the primary heat exchanger varies. Consequently, there is a danger that the refrigerant flowing through the channels of this heat exchanger will change from a turbulent flow to a laminar flow, therewith resulting in a significant change in the Reynold's number and thus in the transfer of heat from the refrigerant to the heat-exchanger channels/conductors through which the refrigerant flows. This problem need not normally occur, provided that the refrigerant cooler is dimensioned correctly.

[0004] No serious problem occurs when the cooler/the heat exchanger has large heat exchanging surfaces, since the transfer of heat from the refrigerant to the heat-exchanging pipe is not a dimensioning factor; on the other hand, the transfer of heat from the pipe to the cooling atmospheric air is a dimensioning factor. Because in the case of the known plant solely the flow of refrigerant through the heat exchanger varies, but not the amount of cooling air, it can be accepted that the flow/flow rate of the refrigerant through heat exchanger pipes will decrease. On the other hand, if the refrigerant cooler/heat exchanger installed in the plant is initially much too small, in other words has relatively small heat exchanging surfaces, this worsening of the heat transfer between the refrigerant and the heat exchanger pipe can have a significant influence and cause the capacity of the refrigerant cooler/ heat exchanger to decrease. Moreover, the fans (or blowers) of the heat exchanging arrangement can consume a relatively large amount of energy when the heat exchanging surfaces of the heat exchanger are meagre, and vice versa. When the heat exchanger has meagre dimensions, this can mean that the amount of energy supplied to the fans/blowers of the heat exchanger must be increased, something that is, of course, undesirable.

[0005] Accordingly, an object of the present invention is to avoid the indicated problem, either completely or partially, in a plant of the described earlier known kind.

[0006] This object is achieved by means of the present invention.

[0007] The invention is defined in the accompanying claim 1.

[0008] In the case of the refrigeration plant described in the introduction, the present invention basically involves driving the pump of the primary heat exchanger so as to deliver a generally constant flow rate; establishing a shunt line between the low pressure side and the high pressure side; providing a flow regulating device for controlling the flow through the shunt line; and providing a pressure difference sensor for controlling the flow regulating device such as to maintain a generally constant pressure difference between the low pressure side and the high pressure side. Thus, the invention enables a constant flow of refrigerant to be maintained through the primary heat exchanger, therewith retaining the turbulence of the refrigerant in the exchanger; while, at the same time, maintaining a constant pressure difference between the high pressure and the low pressure side and allowing a variable flow of refrigerant to the condenser.

[0009] The present invention avails itself of the advantage that a pump that is constructed to run at a fixed speed normally occurs a lower cost that a pump which is designed to be driven at a variable speed.

[0010] Further embodiments of the invention will be apparent from the accompanying dependent claims.

[0011] The condensing pressure of the individual refrigerating plants is controlled by a valve that regulates the refrigerant flow through the condenser. The valve is controlled by the condensing pressure or by the temperature of the exiting refrigerant. Alternatively, the condensing pressure can be controlled by controlling the effective cooling surface in the condenser. This takes place on the refrigerant side (the Freon side) of the system. The thermostat located on the outlet side of the second primary heat exchanger controls activation of the fans/blowers that drive ambient air through said second primary heat exchanger so as to satisfy cooling requirements.

[0012] The invention will now be described with reference to an exemplifying embodiment and also with reference to the accompanying drawings.

Figure 1 illustrates diagrammatically a plant according to the present invention.

Figure 2 illustrates diagrammatically a variant of the plant shown in figure 1.

[0013] The plant comprises a circulation circuit 10 that contains a liquid, such as a glycol/aqueous mixture. The circuit includes a heat consumer, which is represented by a heat exchanger 11 and which transfers heat from the circuit 10 to a heat recovery circuit 14 through which fluid passes. The circuit 10 also includes a primary heat exchanger 20 with which excess heat is emitted to the surroundings, for instance to ambient air.

[0014] The circuit 10 further includes a pump 12 (P2) which drives the refrigerant in the circuit 10 through the heat exchanger 11. Associated with the heat exchanger 20 is a pump 21 (P1) which drives the refrigerant in the circuit 10 in a chosen direction through the heat exchanger 20. The pumps 12, 21 operate in mutually opposite directions and therefore define therebetween a low pressure part 10a in the circuit 10. Alternatively, the circuits 10, 14 may be connected to one another directly, therewith enabling the heat exchanger to be eliminated. The remaining part 10b of the circuit receives refrigerant from the two heat exchangers 11, 12 and therewith forms the high pressure part of the circuit 10. Heat exchangers 31, 32, 33 are connected in parallel between the circuit parts 10a, 10b and are through passed by the refrigerant in the circuit 10 as a result of the pressure difference therebetween.

[0015] The heat exchangers 31-33 are connected at different distances around the circuit parts. The heat exchanger 33 that lies nearest the heat exchanger 11 receives refrigerant of high temperature that defines the condensing temperature of the condenser 53. The next heat exchanger 32 in line may possibly also receive from the heat exchanger 11 refrigerant of elevated temperature, and may also possibly receive a sub-flow of refrigerant from heat exchanger 20, these sub-flows defining the temperature level of the condenser 52. The heat exchanger 31 located closest to the heat exchanger will, of course, be supplied with refrigerant at the temperature defined by the thermostat 23 that controls the fan or blower 26.

[0016] The person skilled in this art will be aware that the heat exchangers 31-33 will, in this order, primarily be supplied with relatively cold refrigerant from the heat exchanger 20, and that the heat exchangers 33-31 will primarily be supplied with relatively warm refrigerant from the heat exchanger 11, and that the division of refrigerant from both of said sources will be set automatically in accordance with demand/supply of heat via the circuit 14.

[0017] The pump 21 is driven at a pre-set constant speed, so as to deliver a generally constant flow of refrigerant to the heat exchanger 20. A pressure difference sensor 22 (GP1) is provided between the circuit parts 10a, 10b. Extending between the circuit parts 10a, 10b is a shunt line 60 which includes a flow regulating device, for instance a throttle valve 61, which is controlled by the pressure difference sensor 22 so as to establish a pre-set constant pressure difference between the circuit parts 10a, 10b. The shunt line 60 connects with the low pressure side 10 immediately downstream of the heat exchanger 20. Provided on the outlet side of the heat exchanger 20 is a temperature sensor (GP3) which controls a fan/blower 26 that regulates the flow of ambient air through the heat exchanger 20 so as to set the surface temperature of the refrigerant from the heat exchanger 20 to a pre-chosen value.

[0018] The pump 12 (P2) is controlled by the heat recovery requirement, wherewith the recovery circuit 14 may include a temperature sensor 13 (GT1) that controls the pump P2. A temperature sensor 16 (GT2) may be connected between the pump 12 and the heat exchanger 11 so as to restrict the temperature of the refrigerant passing to the heat exchanger 11 in an upward sense. In this case none of the delivered heat is passed to the heat exchanger 11?. It will be seen that refrigerant exiting from the heat exchanger 11 first flows through the heat exchanger 33, which thus cools the condenser 53 at a temperature level which is normally relatively high (depending on the return temperature of the recovery circuit). This means that the refrigerating plant (the heat pump) 43 has to operate at a relatively high condensing temperature, i.e. at a relatively low efficiency, although, instead, contributing a relatively large amount of thermal energy to the circuit 14. If not all of the refrigerant from the heat exchanger 11 is passed through the heat exchanger 33, this remaining part of the refrigerant in the low pressure part 10b is forwarded to the heat exchanger 22 which, in such case, also has to operate at a relatively high condenser temperature which, in turn, means that the refrigerating plant 42 (the heat pump) operates at a relatively low efficiency (although contributing heat to the recovery circuit).

[0019] We can now assume that refrigerant from the heat exchanger 20 exits at the temperature defined by the temperature sensor 23 and passes through the heat exchanger 31 and thereafter cools an associated condenser 51 to this temperature and gives a relatively high efficiency to the associated refrigerating plant (the heat pump).

[0020] The person skilled in this art will be aware that the refrigerating plants 41-43 are able to operate at different condensing temperatures, wherein heat is supplied to the heat recovery circuit 14 from the refrigerating plants 43,42,41 that lie closest to the first heat exchanger in that order. The invention achieves a constant flow of refrigerant through the heat exchanger 20 while, at the same time, maintaining a constant pressure difference from the circuit parts 10a, 10b and a variable flow of refrigerant to the condensers.

[0021] The refrigerating plants 41, 42, 43 that lie closes to the second heat exchanger 20, which dumps heat to the ambient air, are able to operate at a high degree of efficiency, i.e. a relatively low condenser temperature, to

the extent that the heat emitted from the condensers 53, 52, 51 is not required to deliver heat to the recovery circuit. The flow of refrigerant through heat exchangers 31, 32, 33 of the circuit 10 is self-adjusting and is controlled by the constant flow generated by the pump 21, the flow shunted through the shunt line 60 and the control valve 61 (which is steered by the pressure difference sensor to create a constant pressure difference between the circuit parts 10a, 10b), and the flow generated by the pump P2 (which, in turn, is controlled by temperature sensor 13 of the recovery circuit), wherein the refrigerating plants 41-43 are able to operate at different condensing temperatures so as to prioritize a high efficiency in respect of given refrigerating plants in a selected order on the one hand, and high heat emission from other refrigerating plants on the other hand?. It will be understood that the mutual distance of the heat exchangers 31-33 from respective heat exchangers 11, 20 is significant to the temperature level at which the corresponding condensers 51-53 can operate.

[0022] The plant provides a manner of controlling the refrigerant in the circuit 10 so that only those refrigerating plants from which surplus heat can be utilized will operate at a high condensing temperature and therewith require higher energy consumption. The distribution of energy to the heat recovery circuit and to the ambient air can be made continuous. There is provided a shunt line 80 between the outlet sides of the pumps 21 and a valve 81, normally closed, in the line 80. A valve 81 can be opened should one of the pumps 21, 12 malfunction. The two pumps 12, 21 function as a reserve for one another, therewith enhancing the operational reliability of the plant. The condensing pressure in respective refrigerating plants is controlled by a valve 70 in the supply line to said condenser heat exchangers 31-33. This valve 70 is controlled by the condensing pressure (not shown) of the plant or by the temperature of the return flow from respective heat exchangers 31-33. Because the flow through the heat exchangers 31-33 is self-regulating no special control valves are required, which is beneficial due to the fact that control valves normally cause pressure drops that must be overcome with the aid of the pumps, i.e. the pump driving energy.

[0023] Each such parallel-connected heat exchangers 31-33 cools a respective condenser 51-53 belonging to a refrigerating plant 41-43.

[0024] By way of an alternative (figure 2) a single refrigerating plant 41' may have a condenser unit that includes 3 series-connected units 51'-53' which operate as hot gas coolers, actually as condensers and condensate-supercoolers respectively, and which are arranged in heat-exchanging relationship with a respective heat exchanger 31-33 at different temperature levels. The refrigeration plant 41' may include an oil cooler 54' which forms a further secondary unit 34 in the heat recovery circuit. The alternative shown in figure 2 also includes a heat pump circuit that may have a drying filter 55 and a refrigerant viewing glass 56 between the condenser 32 and the supercooler 33. The heat pump circuit also includes an evaporator 59 and an expansion valve 60. It will be understood that the heat exchangers 31-34 may be coupled in series, in a temperature order, in the heat recovery circuit 10 (figure 1) optionally together with further units. A pressure difference sensor 22 controls the pump 21 of the heat exchanger 20. The pump 12 of the heat exchanger 11 is controlled by the heat requirement of the recovery circuit 14. The cooling effect of the heat exchanger 20 is controlled by a thermostat 33 on the outlet side of said exchanger 20.

Claims

1. A refrigeration plant comprising a refrigerant circuit (10) filled with a refrigerant and including a first pump (12) for driving refrigerant through a first heat consumer (11, 14) at least two secondary heat exchangers (31-33) which are connected in parallel across conducting parts (10a, 10b) of the circuit (10) said parts (10a, 10b) connecting to the heat consumer (11), wherein the secondary heat exchangers are adapted to cool a respective heat emitting unit (51-53, 51'-53') which is through-passed by refrigerant and which belongs to at least one refrigeration plant (41';41-43), such as a refrigerator or freezer, wherein the refrigerant circuit (10) includes a primary heat exchanger (20) with which heat from the refrigerant is emitted to the environment, preferably to atmospheric air, wherein the secondary heat exchangers (31-33) are coupled in the circuit (10) between the heat consumer and the primary heat exchanger (20) wherein the primary heat exchanger (20) has an affiliated second pump (21) which drives refrigerant in a pre-determined direction through the primary heat exchanger (20), wherein the first affiliated pump (12) is adapted to drive the refrigerant in a pre-determined direction through the heat consumer (11), wherein the first pump (12) and the second pump (21) are adapted to drive the refrigerant in mutually opposite directions such that the circuit will obtain a low pressure side (10a) from which the pumps pump refrigerant, and a high pressure side (10b) to which the pumps pump refrigerant, wherein the plant includes a pressure difference sensor (22) which detects the pressure difference between the low pressure side (10a) of the circuit (10) and a high pressure side (10b) thereof, wherein the first pump (12) is controlled by the heat required by the heat consumer, and wherein the refrigeration plant is **characterized in that** the second pump (21) is adapted to deliver a generally constant flow of refrigerant; **in that** a shunt line (60) is established between the high pressure side (10b) and the low pressure side (10a); **in that** a device (61) is provided for controlling the flow of refrigerant through the shunt line (60); **in that** the flow controlling device (61) is controlled by the pres-

sure difference sensor so as to allow the through-passage of a refrigerant flow that will maintain a generally constant pressure difference between the high pressure side (10b) and the low pressure side (10a).

2. A plant according to claim 1, **characterized in that** the pump (21) of the second primary heat exchanger is a constant speed pump.

3. A plant according to claim 1 or 2, **characterized in that** the heat consumer includes a heat exchanger which is connected in the refrigerant circuit and which is in heat exchanging contact with a heat recovery circuit for cooling said circuit.

4. A plant according to any one claims 1-3, **characterized in that** the second pump (21) is adapted to drive through the primary heat exchanger a flow of refrigerant such as to achieve a turbulent flow in the refrigerant flow channels of the primary heat exchangers.

5. A plant according to claim 4, **characterized in that** the flow is set to the proximity of the low limit for maintaining turbulent flow.

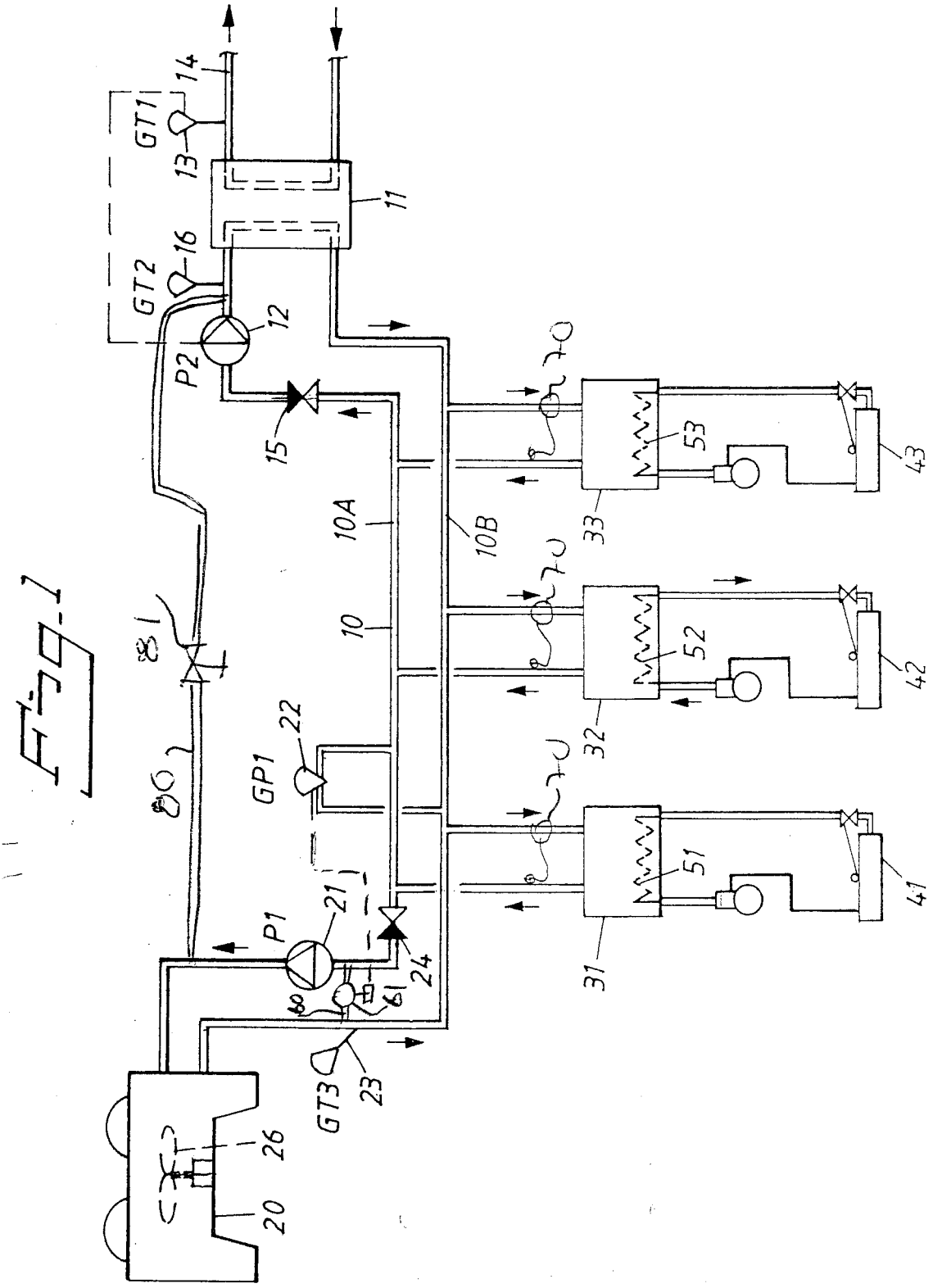

GT1
14
13
11
GT2
16
12
P2
15
10A
10B
10
81
80
GP1
22
P1
21
24
61
GT3
23
26
20
70
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43
33
52
42
32
51
41
31

Fig. 1

Fig. 2

