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(54) **Thermal generator with CO2 operating vapor compression cycle**

(57) Object of the present invention is a vapor compression heat pump comprising at least an air-coolant heat exchanger (1), an expansion valve (7), a compressor (8) which on the delivery line of the compressor is provided with at least two heat exchangers (2,3) exchanging heat with as many secondary circuits (13,14) in each of which the thermo-vector fluid moved by a pump (5,6) passes inside said heat exchangers. The provision of at least two heat exchangers exchanging heat with secondary circuits thermally independent with respect to each other prevents the functioning conditions of one of the secondary circuits from influencing the heat exchange conditions between the other of said secondary circuits and the respective exchanger arranged on the compressor delivery.

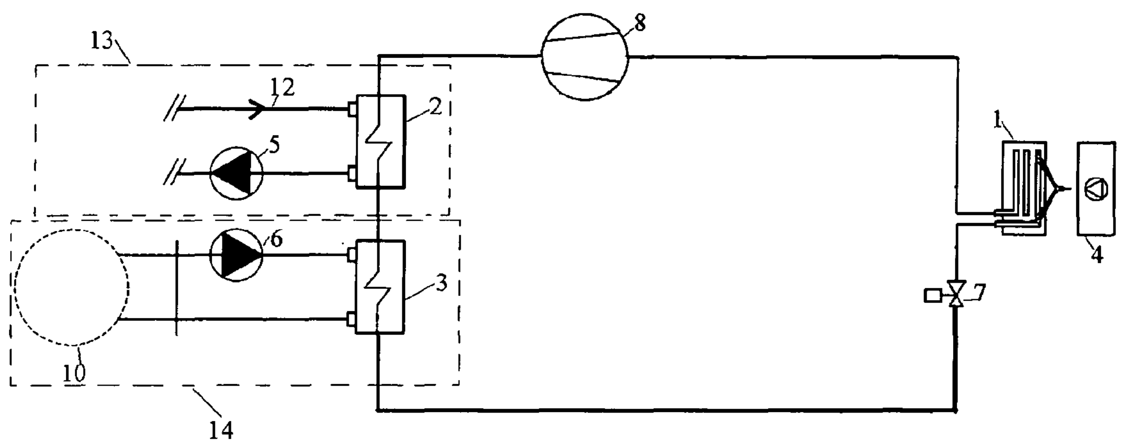

Fig. 1

EP 2 489 944 A1

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Description

[0001] The present patent application relates to a thermal generator with vapor compression cycle optimized for functioning with a CO2 transcritical cycle, studied to make the independent usage of the machine by two different users possible and convenient, which by way of example and in a not limiting way are made up of terminals for heating ambients and for the production of hot water for sanitary usage.

[0002] Up to the 40's, carbon dioxide was very much used as coolant in the cooling systems, thanks to its non-toxic and non-flammable characteristics. But, the high working pressures characterizing its usage had caused its abandoning in favour of the synthetic coolants, characterized by extremely more contained pressures. With the passing of time, the progressive restrictions on the usage of synthetic coolants aimed at limiting the ozone layer thinning and at containing the inlet of greenhouse gases in the atmosphere together with the development of reliable and suitable components for functioning with high pressures, have proposed again carbon dioxide as one of the most interesting natural coolants.

[0003] If it is available a cooling fluid (air or water) at a temperature lower than 20°C, carbon dioxide can be used as any other coolant, operating in a subcritical cycle. Of course the different pressure level requires suitable components and plant measures. If the cooling fluid is available at temperatures higher than 20°C it is necessary to operate according to a so-called transcritical cycle, wherein in the high pressure exchanger typical of a vapor compression cycle, it is no more provided the coexistence of the two phases, but only of the vapor phase.

[0004] In the state of the art, many machines are known which use a CO2 transcritical cycle to provide heat for heating ambients and for the production of sanitary hot water. According to the typical system configuration of these machines, an accumulation tank is used by the heat pump as high temperature heat source, from which the system distributing sanitary hot water draws, and in the upper portion of which a cooling coil is immersed, inside which the thermo-vector fluid used for heating ambients flows. The source constant temperature is guaranteed by making up in the lower portion of the tank the same water quantity as the drawn one for sanitary usage, which is made up at low temperature, typically between 10°C and 15°C. Especially during the night, it often occurs that there is no sanitary hot water demand, and vice versa there is demand for heating ambients. In this case, the water contained in the tank begins to be heated, since the sole subtraction of heat by the cooling coil cannot be sufficient to compensate the heat intake provided by the heat pump. By increasing the hot source temperature, the heat exchanger efficiency cooling CO2 in gaseous phase by heating water and the heat pump efficiency decrease, until the time of stopping the same heat pump is reached.

[0005] At this point, the heating of ambients is provided by the thermal inertia of the tank, which ends in relatively short times, thus lowering the temperature of the water arriving to the system terminals and consequently the efficiency of the same. This phenomenon initiates a cycle beginning with the decreasing of the heat pump efficiency, continuing with the switching off of the same and the consequent decreasing of the efficiency of the ambient terminals, until the same heat pump is switched on again.

[0006] In short the usage of only one heat exchanger between the CO2 circuit and the users, which serves an accumulation tank from which two independent users take heat leads to problems of efficiency of the terminals of the heating system.

[0007] Object of the present invention is to provide a cooling circuit by which a CO2 transcritical vapor compression cycle is operated, which can guarantee constant efficiency in serving two completely independent users.

[0008] These and other advantages will be highlighted by the following description with reference to the appended drawings:

Figure 1 shows a general circuit scheme of the device according to the present invention;
Figure 2 shows an embodiment of the device according to the present invention.

[0009] As shown in figure 1, the circuit according to the present invention comprises at least an air-coolant heat exchanger functioning as an evaporator (1), two water-coolant heat exchangers (2, 3) functioning as gas cooler, since the coolant in the transcritical cycle remains constantly in vapor phase, a fan for the evaporator (4), two pumps (5, 6) for circulating water for the gas cooler, an electronic expansion valve (7), a compressor (8) possibly provided with an exchanger for controlling the temperature of the oil (9), an accumulation tank (10).

[0010] In the circuit there are obviously provided all the devices as for example safety valves and for pressure controlling, temperature sensors, tanks for the coolant commonly adopted for the correct carrying out of the vapor compression cooling cycles and in particular of the cycles operating using CO2 as coolant gas. Such devices, known in the state of the art, are not shown in the drawings without this limiting their usage in the coolant circuit according to the present invention.

[0011] As previously said, the solution used according to the state of the art for the production of both sanitary hot water and hot water for heating purpose at the same time is to use a vertical accumulation tank for sanitary hot water connected with the CO2 functioning machine, wherein the inlet of the CO2 functioning machine delivery is at the top of the tank and the intake is carried out on the bottom where there is connected the make-up system. In the upper portion of the tank there is applied a cooling coil to use the highest temperature and supply terminals with temperatures, which by way of example, can be about 90°C. In a lower area of the tank, where there is water at lower temperature owing to the stratification, there can be applied another cooling coil to supply radiant panels between 30°C and 35°C. As previously explained, without contemporaneously drawing sanitary hot water during the production of hot water for heating purpose, the system efficiency decreases at unacceptable levels thus making a vapor compression cycle useless. Therefore if there is no demand of sanitary hot water, the cycle cannot be carried out.

[0012] This inconvenient in the device according to the present invention is solved because there are two water-coolant heat exchangers (5, 6) connected in series. In the circuit functioning as user, to each heat exchanger there can be mounted a circulation pump (5, 6), possibly provided with electric motor connected to an inverter so that it is possible to change the water flow rate.

[0013] The heat exchanger (2) serving the heating circuit can serve, by way of example, terminals working at water inlet temperature between 80°C and 60°C and output temperature of 30°C, as for example the common radiators, or any kind of water terminal designed for cooling ambients. These terminals working at typical water inlet-output temperatures of 7° and 12°C can work with good thermal performance depending on the heating if supplied between 60° and 80°C at an output temperature of 30°C. The pump (6) mounted in the circuit connected with the heat exchanger (3) for the production of sanitary hot water begins functioning only when there is sanitary hot water demand by the users, and the consequent making up of cold water in the accumulation tank which, by decreasing the inlet water temperature on the user side in the heat exchanger (3) guarantees proper efficiency of the heat exchange in the same exchanger (3).

[0014] Thanks to the series connection of two gas cooler (2, 3), the machine provides the heating function independently from the production of sanitary water. In fact the exchanger (2) is supplied directly by the thermo-vector fluid returning from the ambient terminals, with a temperature difference of at least 30°C between delivery and backflow, which can guarantee an efficient heat exchange in the exchanger (2) and consequently maintain the heat pump efficiency at acceptable levels.

[0015] According to another embodiments shown in figure 2 it is possible to introduce a tank (11) with thermal inertia function on the heating water circuit connected with the exchanger (2). Said tank (11) can be conveniently mounted on the backflow circuit (12) with an accumulation temperature which, by way of example, can be about 30°C. Obviously there have been described only few embodiments of the device, which can be modified by the experts in the art in order to adapt itself to particular applications without departing from the scope of the invention protected by the following claims.

Claims

1. Vapor compression heat pump comprising at least an air-coolant heat exchanger (1), an expansion valve (7), a compressor (8) **characterized in that** on the delivery line of the compressor there are at least two heat exchanger (2, 3) exchanging heat with as many secondary circuits (13, 14) in each of which the thermo-vector fluid moved by a pump (5, 6) passes inside said heat.exchangers (2, 3) .

2. Device according to claim 1, **characterized in that** the provision of at least two said heat exchangers (2, 3) makes said secondary circuits (13, 14) thermally independent with respect to each other, so that the functioning conditions of one said secondary circuits (13, 14) do not influence the heat exchange conditions between the other said secondary circuits and the respective exchanger (2, 3) arranged on the delivery of the compressor (8) .

3. Device according to claim 1, **characterized in that** said heat exchangers (2, 3) are connected in series on the compressor delivery.

4. Device according to any one of claims 1 to 3, **characterized in that** said coolant is carbon dioxide carrying out a transcritical cycle and **in that** said heat exchangers (2, 3) exchange heat between a thermo-vector fluid in liquid phase and the coolant in gaseous phase.

5. Device according to claim 4, **characterized in that** the thermo-vector fluid flow rate and temperature in the backflow sections (12, 15) of each said secondary circuit (13, 14) are adjusted independently for each said secondary circuits (13, 14) in order to optimize the heat exchange efficiency in each said heat exchangers (2, 3) cooling the carbon dioxide in gaseous phase.

6. Device according to any one of the claims 1 to 4, **characterized in that** on one or more said secondary circuits (13, 14) there is provided an accumulation tank of the thermo-vector fluid (11) mounted on the backflow branch of the secondary circuit.

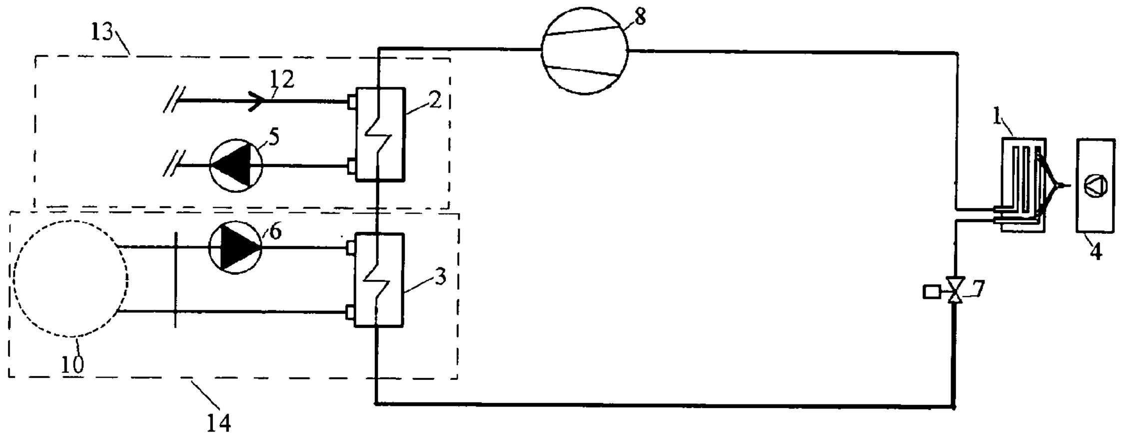

Fig. 1

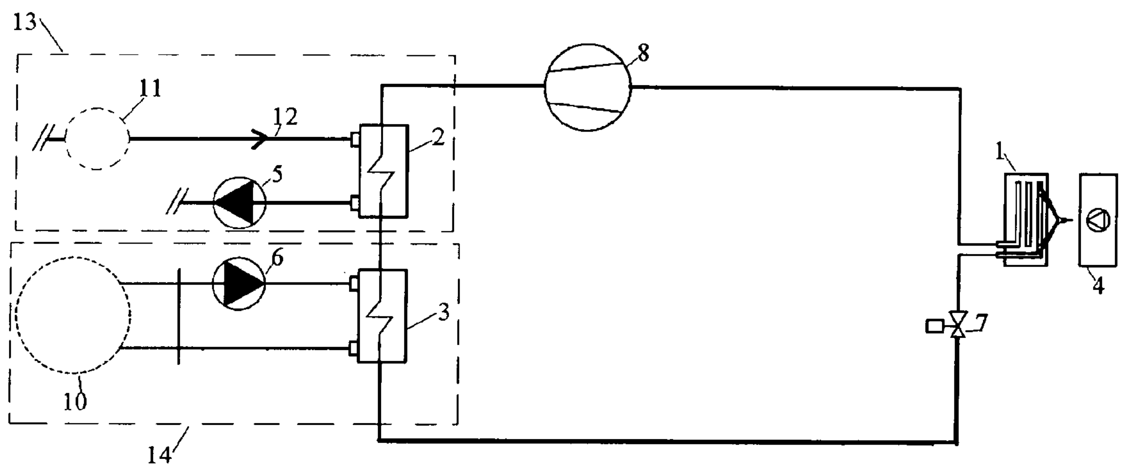

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 42 5040

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2010/064923 A1 (VARMEPUMPEN AS [NO]; HOLM PER ERIK [NO]) 10 June 2010 (2010-06-10) * figure 4 * * page 3, line 30 - line 31 * * page 5, line 15 - line 18 * * page 6, line 22 * * page 7, line 14 - line 19 * -----	1-6	INV. F24D11/02 F25B6/04
X	FR 2 906 603 A1 (HELIOTRANS SARL [FR]) 4 April 2008 (2008-04-04) * figure 16 * -----	1-6	
A	DE 10 2005 002282 A1 (STIEBEL ELTRON GMBH & CO KG [DE]) 27 July 2006 (2006-07-27) * figure 1 * -----	1-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F24D F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 August 2011	Melo Sousa, Filipe

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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E : earlier patent document, but published on, or after the filing date
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4

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 42 5040

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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30-08-2011

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82