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(71) Applicant: **Mirai Intex Sagi**
6830 Chiasso (CH)

(72) Inventor: **Tsyplakov, Vladyslav**
1290 Versoix (CH)

(74) Representative: **Musil, Dobroslav**
Zàbrdovicka 11
615 00 Brno (CZ)

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(54) **AIR COOLING MACHINE**

(57) The invention relates to an air cooling machine comprising a compressor (1) whose inlet (11) is connected to an air outlet (92) of a cooling chamber (9) via a heat exchanger (3), whereby the compressor (1) outlet is connected to an air inlet (91) of the cooling chamber (9) via a cooler (2), the heat exchanger (3) and a turbodetander (4), the turbodetander (4) being coupled to a motor (5) of the compressor (1). Downstream of the outlet (12) of the compressor (1) is connected a bypass air conduit

(61), into which is inserted a bypass valve (6), from which a continuing bypass air conduit (62) terminates downstream of an outlet (42) of the turbodetander (4), whereby a double three-way or block valve (8) is arranged at the air inlet (91) of the cooling chamber (9) and at the air outlet (92) of the cooling chamber (9), and upstream of the air outlet (92) of the cooling chamber (9) a dehumidifier (7) is arranged in the cooling chamber (9).

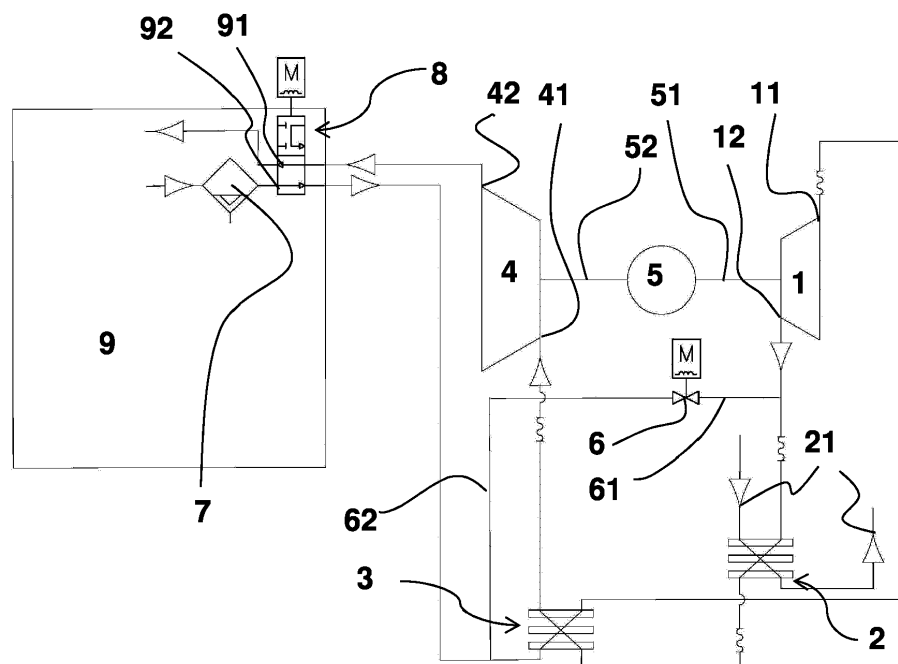


Fig. 2

Description

Technical field

[0001] The invention relates to an air cooling machine comprising a compressor whose inlet is connected to an air outlet of a cooling chamber via a heat exchanger, whereby the compressor outlet is connected to an air inlet of the cooling chamber via a cooler, the heat exchanger and a turbodetander, whereby the turbodetander is coupled to a motor of the compressor.

Background art

[0002] Known are closed cycle regenerative gas cooling machines (see I. A. Sakunin, "Cooling machines", Mashinostroenie, 1985, pp. 360-367, Fig. 8.2), which include a compressor, an embedded cooling device, a detander, a heat exchanger, a motor and a regenerator. The gas flows into the compressor at a certain temperature and pressure, it is compressed and consequently its parameters change, the temperature increases. Thereafter, the gas flows to the embedded cooling device where it is cooled by passing water and is conveyed through the regenerator to the detander. Inside the regenerator, heat is removed from the "direct" stream by heating the "return" stream from the heat exchanger. In the detander, the gas expands and its pressure decreases. Then the gas is supplied to the heat exchanger or a cooling chamber, the gas temperature increases and the gas then passes through the regenerator to the compressor. The required temperatures are achieved by selecting the regeneration depth without increasing the pressure ratios in the compressor.

[0003] The disadvantage of this machine is using the embedded cooling device which makes the machine too complex and limits its use when installed in places where there is no water.

[0004] Also known in the background art is a lamella countercurrent heat exchanger and an air cooling machine for containers (patent application JP 2010025438 A, IPC F28D9/02, F25B9/00, published on 04.02.2010). This document also describes an air cooling machine in which the compressor and detander are located on one shaft and the compressed air is cooled by heat exchange with a stream of "processed" air from a cooling chamber. This arrangement is considered to be the most optimal and represents the closest prior art of the air cooling machine according to the present invention.

[0005] The use of air as a cooling agent causes difficulties caused by the formation of ice (icing) at the point of contact with the object to be cooled inside the air cooling machine and in the air conduits. This is due to the water content in air and to its freezing and removal when the temperature drops. Freezing causes a decrease in the operating efficiency of the air cooling machine due to frequent machine maintenance operations and may lead to the machine being withdrawn from service. It

should be emphasized that, firstly, removing ice from the air conduits and the devices of the air cooling machine is not an easy task; second, it is necessary to stop the system during this operation. This means that air cooling machines have significant limitations in terms of maximum continuous operation time.

[0006] The aim of the invention is therefore to reduce or completely eliminate the disadvantages of the background art, particularly to increase the efficiency of an air cooling machine and ensure the least frequent possible interruptions of the machine operation.

Principle of the invention

[0007] The aim of the invention is achieved by an air cooling machine according to the present invention, whose principle consists in that downstream of an outlet of a compressor is connected a bypass air conduit into which is inserted a bypass valve. A bypass air conduit continuing from the bypass valve terminates downstream of an outlet of a turbodetander, whereby a double three-way or block valve is arranged at an air inlet of a cooling chamber and at an air outlet of the cooling chamber, and a dehumidifier is arranged in the cooling chamber upstream of the air outlet of the cooling chamber. This arrangement ensures that during snow and/or ice removal from the dehumidifier, the double three-way or block valve is brought to a position in which the air from the turbodetander returns to the compressor and does not enter the cooling chamber and pass through the dehumidifier. When the air conduits or the heat exchanger freeze, they can be heated and the snow and ice can be melted without stopping the machine - only by interrupting the air supply to the cooling chamber and by returning this air to the compressor upstream of the cooling chamber, and the warm compressed air from the compressor is supplied via the bypass valve upstream of the heat exchanger, while at the same time the warm compressed air from the compressor is supplied via a cooler in which the cooling air or water supply is stopped.

[0008] To prevent heat loss, a double three-way or block valve is arranged in the cooling chamber.

[0009] Greater defrosting efficiency of the air conduits or the heat exchanger is achieved by inserting a bypass valve between the compressor outlet and the air outlet of the cooling chamber. For defrosting the heat exchanger, it is advantageous if the air from the bypass valve is supplied upstream of the exchanger.

Description of the drawings

[0010] The air cooling machine according to the present invention is schematically represented in the enclosed drawings, wherein Fig. 1 shows a diagram with a double three-way valve, Fig. 2 shows a diagram with a block valve in its operating position during cooling and Fig. 3 shows a diagram in a position during cleaning the dehumidifier or during defrosting.

Examples of embodiment

[0011] The air cooling machine according to the present invention comprises a compressor 1, which is coupled to an electric motor 5 by a shaft 51, and a turbodetander 4. The turbodetander 4 is coupled to the electric motor 5 by means of a shaft 52, thus constituting one assembly with the compressor 1. The motor 5 is coupled to a well-known unillustrated frequency converter which is part of the machine control system and serves to regulate the revolutions of the compressor 1, of the motor 5 and of the turbodetander 4. The inlet 11 of the compressor 1 is connected to an air outlet 92 of the cooling chamber 9 via a heat exchanger 3 (recuperator). The outlet 12 of the compressor 1 is via an air cooler 2 and the heat exchanger 3 connected to the inlet 41 of the turbodetander 4, whose outlet 42 is connected to the air inlet 91 of the cooling chamber 9 via a double three-way or block valve 8. In the cooling chamber 9, upstream of the air outlet 92 of the cooling chamber 9, is arranged a dehumidifier 7, which is connected to the inlet 11 of the compressor 1 via the double three-way or block valve 8 and heat exchanger 3. In the embodiment shown, the double three-way or block valve 8 is arranged in the cooling chamber 9, and so the cooling air which enters the cooling chamber 9 is not heated. Downstream of the outlet 12 of the compressor 1, a bypass air conduit 61 is connected to the outlet air conduit, a bypass valve 6 being inserted into the bypass air conduit 61. In the embodiment shown, downstream of the turbodetander 4, the continuing bypass air conduit 62 opens into the air conduit between the air outlet 92 of the cooling chamber 9 and the heat exchanger 3. In an unillustrated embodiment, the continuing bypass air conduit 62 opens into the cooling chamber 9 in the direction of the air flow downstream of the turbodetander 4 upstream of the double three-way or block valve 8, that is, upstream of the air inlet 91 of the cooling chamber 9.

[0012] The dehumidifier 7 is coupled to a snow and ice conveyor (not shown), which is connected via a pressure valve (not shown) to the environment to which it conveys snow and ice and from which air is sucked through the pressure valve in the event of a pressure drop in the cooling chamber 9.

[0013] Through the air cooler 2 is led a duct 21 through which cooling air or cooling water passes. The described parts of the machine are coupled to a control system of the machine (not shown). Preferably, the control system is provided with a program for automatic control of the machine.

[0014] Air from the cooling chamber 9 is sucked into the compressor 1, where it is compressed and its temperature is increasing. Upon exiting the compressor 1, compressed air enters the air cooler 2, where it is cooled by passing part of its thermal energy to the cooling air or water which is supplied to the cooler 2 via the duct 21 and passes through the cooler 2. From the cooler 2, the compressed air is led to the heat exchanger 3, where it

is further cooled by heat exchange with an air flow which is discharged from the cooling chamber 9 and passes through the heat exchanger 3. The cooled compressed air is supplied to the turbodetander 4, where it expands and consequently is cooled and transmits, through the turbine it rotates, additional torque to the shaft of the machine motor 5, thereby reducing the power consumption of the motor 5 required for the operation of the compressor 1. From the turbodetander 4, the cold air is led to the cooling chamber 9, passing through the double three-way or block valve 8. The cooling performance is changed by varying the speed of the compressor 1 by means of a frequency converter. Increasing the speed of the compressor 1 increases the pressure in the system and, consequently, the degree of expansion in the turbodetander 4, which results in a decrease in the temperature downstream of the turbodetander 4. Supplying cooler air to the cooling chamber 9 reduces also the temperature in the cooling chamber 9.

[0015] Air from the cooling chamber 9 is discharged through the dehumidifier 7, in which moisture from air is collected from air in the form of snow and/or ice. In the event that the amount of snow and/or ice in the dehumidifier 7 reaches a preset limit, the double three-way or block valve 8 moves to a position in which the supplied air does not enter the cooling chamber 9, but returns from the valve 8 via the exchanger 3 to the compressor 1, as shown in Fig. 3. In this mode, snow and/or ice is removed from the dehumidifier 7, whereby neither the dehumidifier 7, nor the cooling machine is heated. After removing snow and/or ice from the dehumidifier 7, the double three-way or block valve 8 returns to its operating position and air from the turbodetander 4 is again fed to the cooling chamber 9 and passes through the dehumidifier 7.

[0016] In the case of low temperatures during long-term operation, when air conduits freeze and/or snow and ice (water in a solid state) is deposited in the heat exchanger 3, whether in the part through which the compressed air passes from the compressor 1 or in the part through which air from the cooling chamber 9 passes, it is necessary to prevent complete freezing of the air conduits and/or the heat exchanger 3. For that purpose, the bypass valve 6 opens, the supply of the cooling air or cooling water to the cooler 2 is stopped and the double three-way or block valve 8 moves to a position in which the supplied air does not enter the cooling chamber 9, but returns from the valve 8 through the heat exchanger 3 to the compressor 1, as shown in Fig. 3, whereby, before entering the heat exchanger 3, it is mixed with the warm compressed air which passes through the bypass valve 6. At the same time, the compressed and warm air from the outlet 12 of the compressor 1 which is not cooled in the cooler 2 enters the heat exchanger 3. This results in the heating of the air conduits and/or the heat exchanger 3 and the dissolving of the snow or ice in them. Consequently, air from the cooling chamber 9 can again pass through the air conduits and the heat exchanger 3 after the valve 8 changes its position and the bypass valve 6

closes, whereby the air leaving the compressor 1 is again cooled in the cooler 2. In the above described unillustrated embodiment, the warm compressed air passing through the bypass valve 6 is supplied downstream of the turbodetander 4 upstream of the double three-way or block valve 8, that is, upstream of the air inlet 91 of the cooling chamber 9.

Industrial applicability

[0017] The invention relates to the field of refrigeration technology and can be used for production of cooling units, freezing chambers, rapid cooling systems, air conditioning systems and/or temperature maintenance systems.

List of references

[0018]

1	compressor	20
11	compressor inlet	
12	compressor outlet	
2	air cooler	
3	heat exchanger	25
4	turbodetander	
41	turbodetander inlet	
42	turbodetander outlet	
5	motor	
51	shaft of the compressor	30
52	shaft of the turbodetander	
6	bypass valve	
61, 62	bypass air conduits	
7	dehumidifier	
8	double three-way or block valve	35
9	cooling chamber	
91	air inlet of the cooling chamber	
92	air outlet of the cooling chamber	

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Claims

1. An air cooling machine comprising a compressor (1) whose inlet (11) is connected to an air outlet (92) of a cooling chamber (9) via a heat exchanger (3), whereby the compressor (1) outlet is connected to an air inlet (91) of the cooling chamber (9) via a cooler (2), the heat exchanger (3) and a turbodetander (4), the turbodetander (4) being coupled to a motor (5) of the compressor (1), **characterized in that** downstream of the outlet (12) of the compressor (1) is connected a bypass air conduit (61) into which is inserted a bypass valve (6) from which a continuing bypass air conduit (62) terminates downstream of an outlet (42) of the turbodetander (4), whereby a double three-way or block valve (8) is arranged at the air inlet (91) of the cooling chamber (9) and at the air outlet (92) of the cooling chamber (9), and

upstream of the air outlet (92) of the cooling chamber (9) a dehumidifier (7) is arranged in the cooling chamber (9).

2. The air cooling machine according to claim 1, **characterized in that** a double three-way or block valve (8) is arranged in the cooling chamber (9).
3. The air cooling machine according to claim 1 or 2, **characterized in that** the continuing bypass air conduit (62) terminates between the air outlet (92) of the cooling chamber (9) and the heat exchanger (3).
4. The air cooling machine according to claim 1 or 2, **characterized in that** the continuing bypass air conduit (62) terminates upstream of the double three-way or block valve (8).

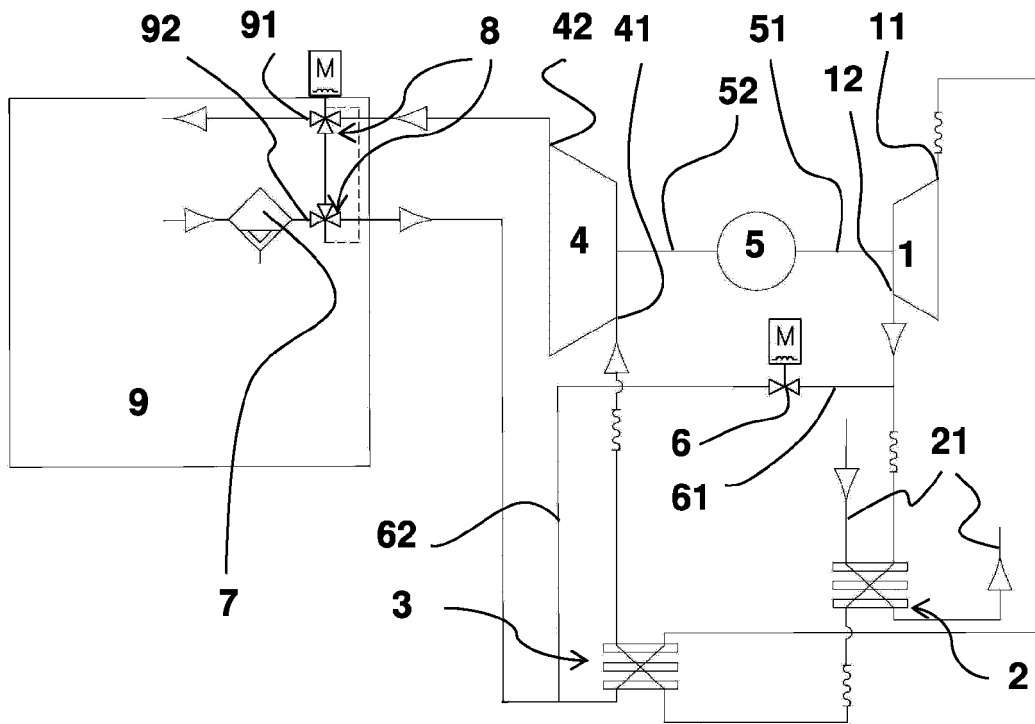


Fig. 1

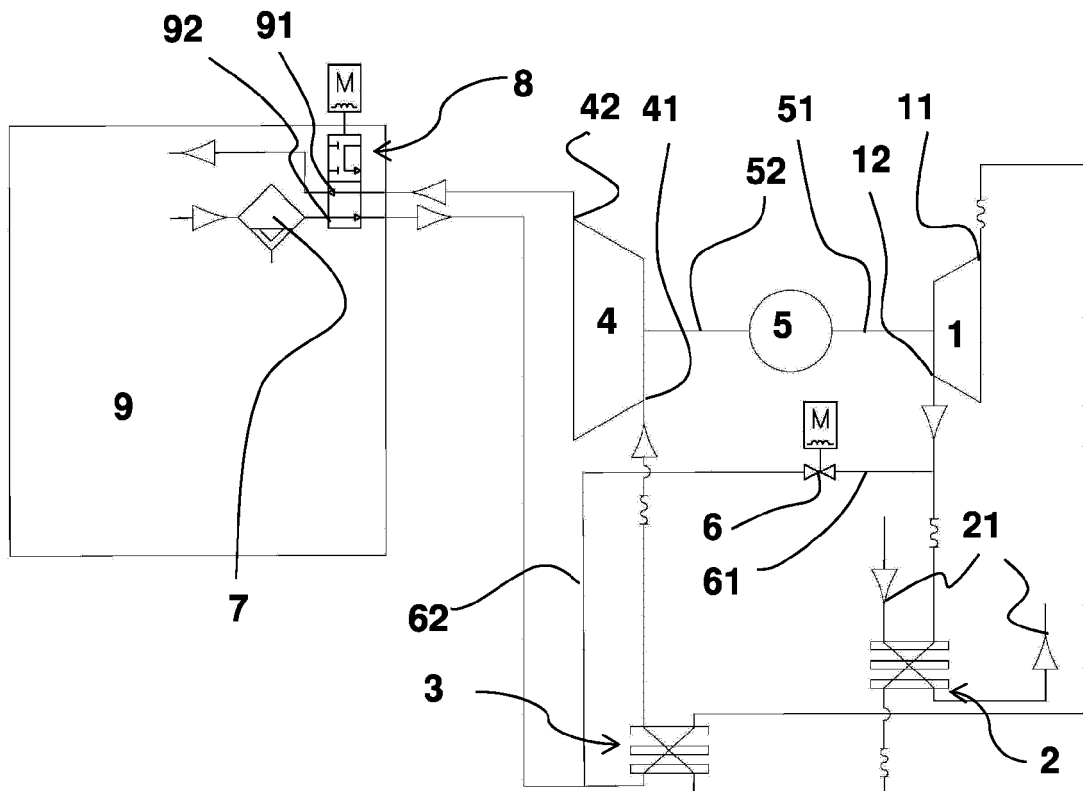


Fig. 2

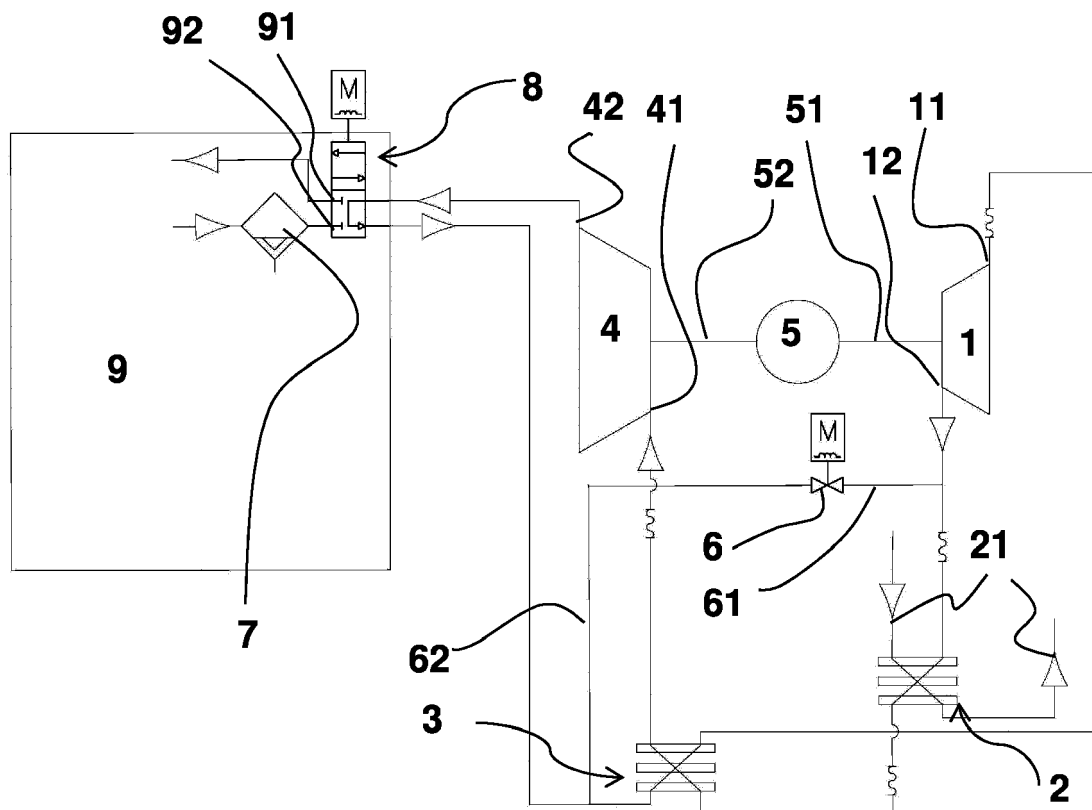


Fig. 3



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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
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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 P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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