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(54) **AIR COOLING MACHINE**

LUFTKÜHLMASCHINE

MACHINE DE REFROIDISSEMENT D'AIR

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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] JP 2012 137218 A discloses an air cooling machine which comprises a compressor the inlet of which is connected via a heat exchanger and a dehumidifier to an air outlet from a cooling chamber, whereby the outlet of the compressor is via a cooler, the heat exchanger and a turbodetander connected to the air inlet from the cooling chamber and the turbodetander is coupled to the motor of the compressor. Downstream of the outlet of the compressor, a bypass air conduit is connected via the cooler and a bypass valve. The bypass air conduit leads to the inlet of the turbodetander, whereby downstream of the outlet of the turbodetander there is a continuous bypass air conduit with a bypass valve which ends downstream of the air outlet from the cooling chamber, upstream of the dehumidifier which is arranged outside the cooling chamber and from the outlet of the dehumidifier, the air is guided via the heat exchanger to the inlet of the compressor. The disadvantage of this solution is the fact that the defrosting of the dehumidifier cannot be separated from the defrosting of the air conduits and the heat exchanger. The dehumidifier is arranged outside the cooling chamber in warm environment, which does not allow to remove snow and/or ice, because it will melt and freeze again and again, which results the the dehumidifier failure. Defrosting the heat exchanger will be extremely difficult, since all the air for defrosting flows from the compressor through the bypass air conduit to the turbodetander and from the turbodetander it continues via the dehumidifier and only then to the heat exchanger.

[0005] EP 1022521 A1 describes the provision of space heating and cooling by means of three four-way valves and the organization of return flow in some parts of the device, but does not allow the achievement of low temperatures because it does not comprise a heat exchanger. The solution is designed to maintain climatic conditions in the room and cannot be used in an air cooling machine, which should achieve low temperatures, i.e. temperatures below -60 °C.

[0006] 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.

[0007] 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.

[0008] 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

[0009] The aim of the invention is achieved by an air cooling machine according to claim 1, whose principle consists in that downstream of an outlet of a compressor is for defrosting air conduits and a heat exchanger connected a bypass air conduit into which is inserted a bypass valve, openable for defrosting the air conduits and/or the heat exchanger, when the supply of cooling air or cooling water to the radiator is stopped, and a bypass air conduit continuing from the bypass valve terminates downstream of an outlet of a turbodetander, upstream of the heat exchanger for supplying warm air from the compressor outlet, whereby a first and second three-way valve or four-way two-position valve is arranged inside a cooling chamber at the air inlet of a cooling chamber and at the air outlet of the cooling chamber, whereby the valve is displaceable for defrosting the air conduits and/or the heat exchanger to a position in which the supplied air does not enter the cooling chamber, but returns from the first and second three-way valve or four-way two-position valve via the exchanger to the compressor, 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 first and second three-way valve or four-way two-position 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.

[0010] To prevent heat loss, a valve is arranged in the cooling chamber.

[0011] Greater defrosting efficiency of the air conduits or the heat exchanger is achieved by exiting the continuing bypass valve between the second three-way valve or four-way two-position valve and the heat exchanger. For defrosting the heat exchanger, it is advantageous if warm air from the bypass valve is supplied upstream of the exchanger.

[0012] Another option for arranging the supply of warm compressed air from the compressor via the bypass valve is the exiting of the continuing bypass air duct from the bypass valve downstream of the outlet of the turbodetander and upstream of the first and second three-way valve or four-way two-position valve.

Description of the drawings

[0013] The air cooling machine according to the present invention is schematically represented in the enclosed drawings, wherein Fig. 1 shows a diagram with a two three-way valve, Fig. 2 shows a diagram with a 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

[0014] 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 convertor 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 first three-way valve **8** or a four-way two-position 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 first three-way valve **8** or four-way two-position valve **8** and heat exchanger **3.** In the embodiment shown, the the first and second three-way valve **8** or four-way two-position 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 first three-way valve **8** or four-way two-position valve **8,** that is, upstream of the air inlet **91** of the cooling chamber 9.

[0015] 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.**

[0016] 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.

[0017] 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 first and second three-way valve **8** or the four-way two-position 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.**

[0018] 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 first and second three-way valve **8** or the four-way two-position valve 8 moves to a position in which the supplied air does not enter the cooling chamber **9,** but returns from the first and second three-way valve **8** or the four-way two-position 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 first and second three-way valve **8** or the four-way two-position 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.**

[0019] 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 first and second three-way valve **8** or the four-way two-position valve **8** moves to a position in which the supplied air does not enter the cooling chamber **9,** but returns from the first and second three-way valve **8** or the four-way two-position 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 first and second three-way valve **8** or the four-way two-position 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 first and second three-way valve **8** or the four-way two-position valve **8,** that is, upstream of the air inlet **91** of the cooling chamber **9.**

Industrial applicability

[0020] 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

[0021]

1	compressor
11	compressor inlet
12	compressor outlet
2	air cooler
3	heat exchanger
4	turbodetander
41	turbodetander inlet
42	turbodetander outlet
5	motor
51	shaft of the compressor
52	shaft of the turbodetander
6	bypass valve
61, 62	bypass air conduits
7	dehumidifier
8	first and second three-way valve or four-way two-position valve
9	cooling chamber
91	air inlet of the cooling chamber
92	air outlet of the cooling chamber

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 a compressor outlet (12) 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), wherein downstream of the outlet (12) of the compressor (1) is for defrosting air conduits and/or the heat exchanger (3) connected a bypass air conduit (61) into which is inserted a bypass valve (6) which is openable for defrosting the air conduits and/or the heat exchanger (3, wherein when the bypass valve (6) opens, the supply of cooling air or cooling water to the cooler (2) is closed, and a bypass air conduit (62) continuing from the bypass valve (6) terminates downstream of an outlet (42) of the turbodetander (4), upstream of the heat exchanger (3) and is configured for supplying warm air from the compressor (1) outlet, whereby a first and second three-way valve (8) are arranged inside the cooling chamber (9) respectively at the air inlet (91) of the cooling chamber (9) and at the air outlet (92) of the cooling chamber (9) or a four-way two-position valve (8) is arranged inside the cooling chamber (9) at the air inlet (91) of the cooling chamber (9) and at the air outlet (92) of the cooling chamber (9), whereby the first and second three-way valve (8) or the four-way two-position valve (8) are displaceable to a position in which the supplied air does not enter the cooling chamber (9), but returns from the first and second three-way valve (8) or the four-way two-position valve (8) via the heat exchanger (3) to the compressor (1) for defrosting the air conduits and/or the heat exchanger (3) when the bypass valve (6) opens, whereby 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** the continuing bypass air conduit (62) terminates between the second three-way valve (8) or the four-way two-position valve (8) and the heat exchanger (3).

3. The air cooling machine according to claim 1, **characterized in that** the continuing bypass air conduit (62) terminates upstream of the first and second three-way valve (8) or the four-way two-position valve (8).

Patentansprüche

1. Luftkühlmaschine, die einen Kompressor (1) aufweist, dessen Eingang (11) über einen Wärmetauscher (3) an einen Ausgang (92) der Luft aus einer Kühlkammer (9) angeschlossen ist, wobei der Ausgang (12) des Kompressors (1) über Kühler (2), Wärmetauscher (3) und Turbodetander (4) an einen Eingang (91) der Luft in die Kühlkammer (9) angeschlossen ist und der Turbodetander (4) mit dem Motor (5) des Kompressors (1) verkoppelt ist, wobei hinter dem Ausgang (12) des Kompressors (1) zum Auftauen von Luftleitungen und/oder Wärmetauscher (3) eine Umführungsluftleitung (61) angeschlossen ist, in die ein Umführungsventil (6) hineingelegt ist, das zum Auftauen von Luftleitungen und/oder Wärmetauscher (3) öffenbar ist, wobei wenn das Umführungsventil (6) geöffnet ist, ist die Kühlluft- oder Kühlwasserzufuhr in den Kühler (2) gestoppt, und die von dem Umführungsventil (6) fortlaufende Umführungsluftleitung (62) hinter dem Ausgang (42) des Turbodetanders (4) vor dem Wärmetauscher (3) eingemündet ist und zum Zuführen der warmen Luft aus dem Ausgang des Kompressors (1) konfiguriert ist, wobei das erste und zweite Dreiwegeventil innerhalb der Kühlkammer, bzw. am Eingang (91) der Luft in die Kühlkammer (9) und am Ausgang (92) der Luft aus der Kühlkammer (9) angeordnet sind, oder innerhalb der Kühlkammer (9) ein Zweilagen-Vierwegeventil (8) am Eingang (91) der Luft der Kühlkammer und am Ausgang (92) der Kühlkammer angeordnet ist, wobei das erste und zweite Dreiwegeventil (8) oder das Zweilagen-Vierwegeventil (8) in solche Lage verstellbar sind, in der die zugeführte Luft in die Kühlkammer (9) nicht eintritt, sondern aus dem ersten und zweiten Dreiwegeventil (8) oder Zweilagen-Vierwegeventil (8) über den Wärmetauscher (3) in den Kompressor (1) zum Auftauen von Luftleitungen und/oder Wärmetauscher (3) zurückgeführt wird, wenn das Umführungsventil geöffnet ist, wobei vor dem Ausgang (92) der Luft aus der Kühlkammer (9) in der Kühlkammer (9) ein Entfeuchter (7) angeordnet ist.

2. Luftkühlmaschine nach dem Anspruch 1, **dadurch gekennzeichnet, dass** die fortlaufende Umführungsluftleitung (62) zwischen dem zweiten Dreiwegeventil (8) oder dem Zweilagen-Vierwegeventil (8) und dem Wärmetauscher (3) ausgemündet ist.

3. Luftkühlmaschine nach dem Anspruch 1, **dadurch gekennzeichnet, dass** die fortlaufende Umführungsluftleitung (62) vor dem ersten und zweiten Dreiwegeventil (8) oder dem Zweilagen-Vierwegeventil (8) ausgemündet ist.

Revendications

1. Machine de refroidissement de l'air comprenant un compresseur (1) dont l'entrée (11) est reliée par un échangeur (3) de chaleur à la sortie (92) d'air de la chambre de refroidissement (9), tandis que la sortie (12) du compresseur (1) est reliée par l'intermédiaire d'un refroidisseur (2), un échangeur (3) de chaleur et un turbodétendeur (4) à l'entrée (91) d'air dans la chambre de refroidissement (9) et le turbodétendeur (4) est couplé au moteur (5) du compresseur (1), tandis qu'un conduit de dérivation (61) est relié en

aval de la sortie (12) du compresseur (1) pour le dégivrage des conduits d'air et/ou de l'échangeur (3) de chaleur, dans lequel est insérée une soupape de dérivation (6) avec ouverture pour le dégivrage des conduits d'air et/ou de l'échangeur (3) de chaleur, de sorte que lorsque la soupape de dérivation (6) est ouverte, l'alimentation en air de refroidissement ou en eau de refroidissement du refroidisseur (2) est interrompue, et un conduit de dérivation (62) partant de la soupape de dérivation (6) est déchargé en aval de la sortie (42) du turbodétendeur (4) en amont de l'échangeur (3) de chaleur et est configuré pour fournir de l'air chaud à partir de la sortie du compresseur (1), tandis que la première et la deuxième vanne à trois voies sont disposées à l'intérieur de la chambre de refroidissement, ou alternativement, à l'entrée (91) de l'air de la chambre de refroidissement et à la sortie (92) de l'air de la chambre de refroidissement (9), ou une vanne à quatre voies à deux positions (8) est disposée à l'intérieur de la chambre de refroidissement (9) - à l'entrée (91) de l'air de la chambre de refroidissement et à la sortie (92) de la chambre de refroidissement, tandis que la première et la deuxième vanne à trois voies (8) ou la vanne à quatre voies à deux positions (8) sont repositionnables, dans laquelle l'air d'alimentation n'entre pas dans la chambre de refroidissement (9) mais revient de la première et la deuxième vanne à trois voies (8) ou de la vanne à quatre voies à deux positions (8) à l'intermédiaire de l'échangeur (3) de chaleur vers le compresseur (1) pour dégivrage des conduits d'air et/ou l'échangeur (3) de chaleur lorsque la soupape de dérivation est ouverte, tandis qu'un déshumidificateur (7) est disposé dans la chambre de refroidissement (9) en amont de la sortie (92) de l'air provenant de la chambre de refroidissement (9).

2. Machine de refroidissement de l'air selon la revendication 1, **caractérisée en ce que** le conduit de dérivation continue (62) est déchargé entre la deuxième vanne à trois voies (8) ou la vanne à quatre voies à deux positions (8) et l'échangeur (3) de chaleur.

3. Machine de refroidissement de l'air selon la revendication 1, **caractérisée en ce que** le conduit de dérivation continue (62) est déchargé en amont de la première et la deuxième vanne à trois voies (8) ou de la vanne à quatre voies à deux positions (8).

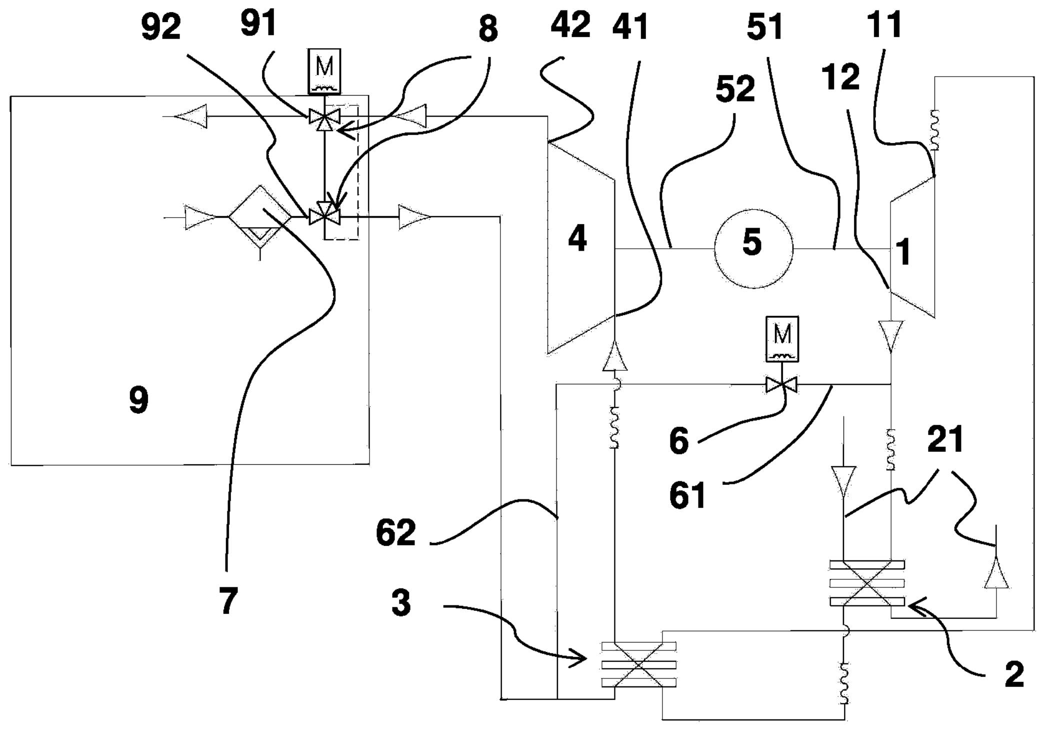
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Fig. 1

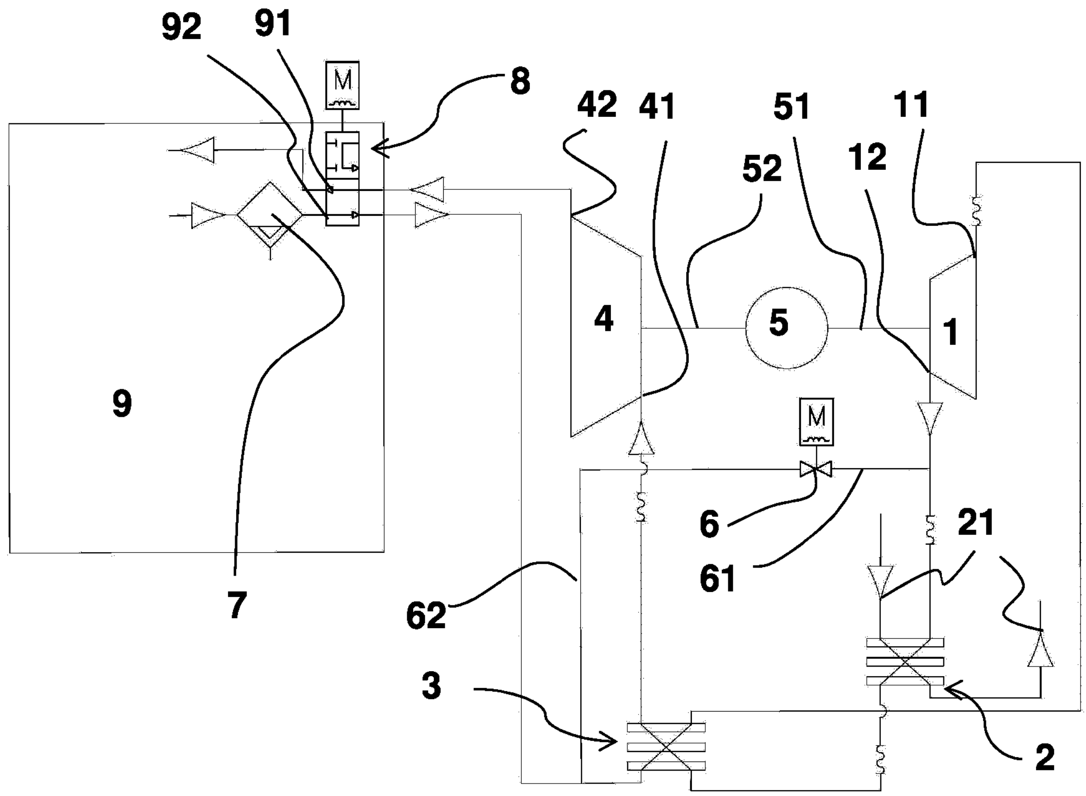
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Fig. 2

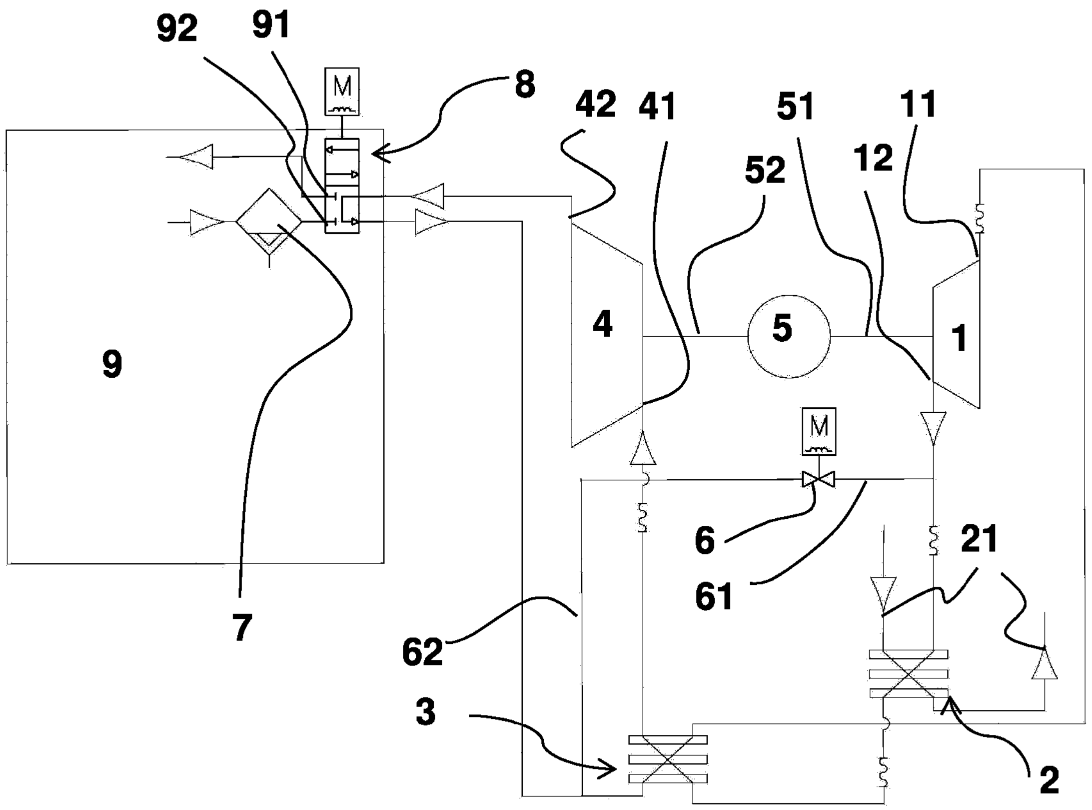

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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