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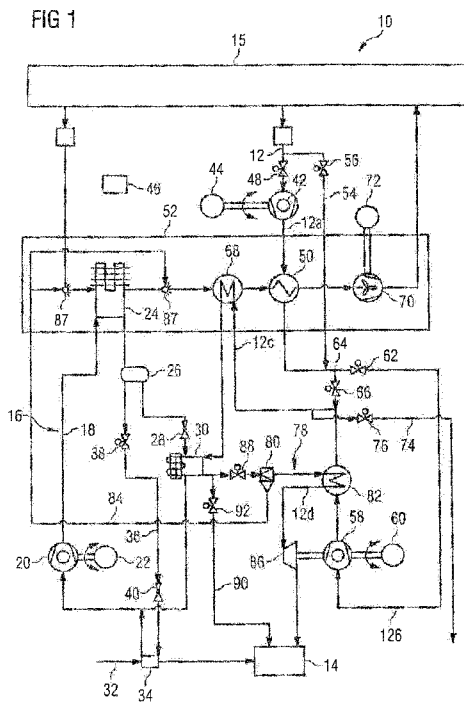
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(54) **Title:** ELECTRICALLY DRIVEN AIRCRAFT AIR CONDITIONING SYSTEM AND METHOD FOR OPERATING SUCH
AN AIRCRAFT AIR CONDITIONING SYSTEM

FIG 1

(57) **Abstract:** An aircraft air conditioning system (10) comprises an ambient
air line (12) which is adapted to be flown through with ambient air and
which is connected to a mixer (14) of the aircraft air conditioning system
(10), in order to feed ambient air into the mixer (14), at least one ambient air
compressor (42, 58) arranged in the ambient air line (12) for compressing the
ambient air flowing through the ambient air line (12), a refrigerating machine
(16), which comprises a refrigerant circuit (18) adapted to be flown through
with a refrigerant as well as a refrigerant compressor (20) arranged in the re-
frigerant circuit (18), wherein the refrigerant circuit (18) is thermally coupled
to the ambient air line (12) in order to transfer heat from the ambient air
flowing through the ambient air line (12) to the refrigerant circulating in the
refrigerant circuit (18) before the ambient air is fed into the mixer (14), and
at least one electric motor (22, 44, 60) for driving the at least one ambient air
compressor (42, 58) and/or the refrigerant compressor (20).

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Electrically driven aircraft air conditioning system and method for
operating such an aircraft air conditioning system

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The invention relates to an aircraft air conditioning system and a method for operating an aircraft air conditioning system.

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An aircraft air conditioning system is used to set and maintain a desired pressure, a desired temperature and a desired atmospheric humidity in an aircraft cabin.

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Moreover, the aircraft air conditioning system feeds sufficient fresh air into the aircraft cabin to ensure that a prescribed minimum proportion of fresh air is present in the aircraft cabin. An aircraft air conditioning system is known from EP 2 735 510 A1 and US 2014/0144163 A1 in which a refrigerating machine operated using a two-phase refrigerant is used to cool ambient air compressed by a multistage compressor. The refrigerating machine comprises a refrigerant circuit in which a compressor, a liquefier, an expansion valve and an evaporator, through which ambient air to be cooled flows, are arranged. Bleed air drawn from an engine or an auxiliary engine of the aircraft is used to drive the compressor of the refrigerating machine and to drive the multistage compressor for compressing the ambient air.

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The object of the invention is to provide an aircraft air conditioning system that facilitates energy-efficient and fuel-saving air conditioning of an aircraft cabin. A further object of the invention is to specify a method for operating such an aircraft air conditioning system.

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This object is achieved by an aircraft air conditioning system with the features of claim 1 and a method for operating an aircraft air conditioning system with the features of claim 13.

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An aircraft air conditioning system comprises an ambient air line which is adapted to be flown through with ambient air and which is connected to a mixer of the aircraft air conditioning system, in order to feed the mixer with ambient air taken from an aircraft's surroundings. The mixer connected to the ambient air line may be a premixer or a main mixer of the aircraft air conditioning system into which, apart from ambient air from the ambient air line, recirculation air discharged from an

- 2 -

aircraft cabin to be air conditioned by the aircraft air conditioning system is fed. In the mixer, the ambient air from the ambient air line is mixed with the recirculation air discharged from the aircraft cabin. The mixed air produced in the mixer is finally used for air conditioning the aircraft cabin.

Furthermore, the aircraft air conditioning system comprises at least one ambient air compressor arranged in the ambient air line for compressing the ambient air flowing through the ambient air line. A refrigerating machine of the aircraft air conditioning system comprises a refrigerant circuit adapted to be flown through with a refrigerant and a refrigerant compressor arranged in the refrigerant circuit. An air conditioning process consequently takes place in the aircraft air conditioning system in which the ambient air is first compressed by the ambient air compressor and then cooled to a desired temperature by the transfer of heat to the refrigerant circulating in the refrigerant circuit of the refrigerating machine. By appropriate precompression of the ambient air in the ambient air compressor, the efficiency of this air conditioning process can be controlled as required.

Finally, the aircraft air conditioning system comprises at least one electric motor for driving the at least one ambient air compressor and/or the refrigerant compressor. In the aircraft air conditioning system, bleed air drawn from an engine or an auxiliary engine of the aircraft is consequently dispensed with not only in the provision of air conditioning air, but also when driving the ambient air compressor and/or the refrigerant compressor. This reduces the fuel consumption of the engine or auxiliary engine. Furthermore, the use of an electric drive for the ambient air compressor and/or the refrigerant compressor and the use of ambient air to provide air conditioning air facilitate complete decoupling of the energy and fresh air feed to the aircraft air conditioning system. Due to this, the energy feed and fresh air feed can be optimised independently of one another and adapted, for example, to the operating conditions of the aircraft air conditioning system. The aircraft air conditioning system can therefore be operated in a particularly energy-efficient manner.

The refrigerant circulating in the refrigerant circuit of the refrigerating machine is preferably a two-phase refrigerant, which on taking up heat from the ambient air flowing through the ambient air line passes from the liquid into the gaseous state and is then returned to the liquid state by corresponding pressure and temperature control in the refrigerant circuit of the refrigerating machine. For example, R134A

- 3 -

(CH₂F-CF₃), CO₂ or R-245fa (1,1,1,3,3,pentafluoropropane) may be circulated in the refrigerant circuit of the refrigerating machine as a two-phase refrigerant. The cooling process used to cool the ambient air flowing through the ambient air line is consequently preferably realised as a cold vapour process, which is distinguished by a high level of energy efficiency.

Apart from the refrigerant compressor preferably driven by a first electric motor, a liquefier, a refrigerant collector and an expansion valve may be arranged in the refrigerant circuit of the refrigerating machine. Furthermore, the refrigerant circuit is preferably thermally coupled to the ambient air line via a heat exchanger, in order to transfer heat from the ambient air flowing through the ambient air line to the refrigerant circulating in the refrigerant circuit before the ambient air is fed into the mixer. Therefore, also a heat exchanger for establishing the thermal coupling between the refrigerant circuit of the refrigerating machine may be arranged in the refrigerant circuit of the refrigerating machine. The heat exchanger used for establishing the thermal coupling between the refrigerant circuit of the refrigerating machine and the ambient air line preferably is designed in the form of an evaporator. The pressure and temperature control in the refrigerant circuit of the refrigerating machine is preferably realised in such a way that the cold vapour process executed in the refrigerant circuit proceeds predominantly in the two-phase region of the two-phase refrigerant, due to which isothermals and isobars coincide. The cold vapour process consequently approximates to the theoretically optimal Carnot cycle, due to which particularly efficient cooling of the ambient air flowing through the ambient air line is made possible.

The refrigerant circuit of the refrigerating machine may also be thermally coupled to a recirculation air line adapted to be flown through with recirculation air, in order to transfer heat from the recirculation air flowing through the recirculation air line to the refrigerant flowing through the refrigerant circuit. The recirculation air line is preferably connected to the mixer of the aircraft air conditioning system, to feed recirculation air to the mixer. If the refrigerating machine is used not only for cooling the ambient air flowing through the ambient air line, but also for cooling recirculation air taken from the aircraft cabin to be air conditioned, the recirculation air can be cooled before being fed into the mixer of the aircraft air conditioning system to the same low temperature as the ambient air flowing through the ambient air line.

- 4 -

Cooling the ambient air by heat transfer to the refrigerant circulating in the refrigerant circuit of the refrigerating machine to a temperature below a desired set cabin feed air temperature can consequently be dispensed with, due to which the operating efficiency of the aircraft air conditioning system is further improved.

5 Operation of the refrigerating machine at relatively high minimum refrigerant temperatures is also made possible, so that the risk of icing for components arranged in the refrigerant circuit of the refrigerating machine, for example the heat exchanger or the liquefier, can be minimised.

10 The refrigerant circuit of the refrigerating machine may be thermally coupled to the recirculation air line via a further heat exchanger, in particular a further evaporator. The further heat exchanger is preferably arranged in a connection line that branches off from the refrigerant circuit of the refrigerating machine upstream of the heat exchanger which thermally couples the refrigerant circuit to the ambient air line and that opens back into the refrigerant circuit of the refrigerating machine downstream
15 of the heat exchanger which thermally couples the refrigerant circuit to the ambient air line. The terms "upstream" and "downstream" here refer to the direction of flow of the refrigerant through the refrigerant circuit. In particular, the connection line branches off from the refrigerant collector arranged in the refrigerant circuit. Such a
20 design of the refrigerant circuit makes it possible to provide the heat exchanger used for cooling the ambient air flowing through the ambient air line and the further heat exchanger used for cooling the recirculation air flowing through the recirculation air line with refrigerant in parallel and to regulate them independently of one another. The refrigerant collector is used in this case as a refrigerant buffer, which guarantees
25 an adequate provision of refrigerant to both heat exchangers.

A control valve may be arranged in the connection line, which control valve is configured to control the refrigerant flow through the connection line. The refrigerant flow through the connection line can be adapted to the cooling requirement of the
30 recirculation air to be cooled by appropriate control of the control valve. Furthermore, the refrigerant circulating in the refrigerant circuit of the refrigerating machine can be distributed by appropriate control of the control valve to the heat exchanger for cooling the ambient air and the further heat exchanger for cooling the recirculation air as a function of the cooling requirement of the ambient air to be cooled and as a
35 function of the cooling requirement of the recirculation air to be cooled. This facilitates a prioritisation if required of the heat exchanger or of the further heat exchanger with regard to the feed of refrigerant.

- 5 -

Furthermore, a further expansion valve may be arranged in the connection line. Due to the further expansion valve arranged in the connection line upstream of the further heat exchanger relative to the flow direction of the refrigerant through the refrigerant circuit, the pressure and the temperature of the refrigerant flowing through the connection line can be set as desired before the refrigerant is conducted into the further heat exchanger.

The ambient air line may comprise a first section in which a first ambient air compressor is arranged for compressing the ambient air flowing through the first section of the ambient air line. The first ambient air compressor, which is speed-regulated, for example, is preferably driven by a second electric motor. The first ambient air compressor may be controlled by a control device of the aircraft air conditioning system, for example, in such a way that it compresses the ambient air flowing through the first section of the ambient air line, which air can naturally have a pressure lying considerably below the atmospheric pressure at sea level in flight mode of an aircraft equipped with the aircraft air conditioning system, only to the set cabin pressure in the aircraft cabin to be air conditioned. The first ambient air compressor can therefore be operated very energy-efficiently. A first valve may be arranged in the first section of the ambient air line, which may be configured to control the ambient air flow through the first section of the ambient air line.

Furthermore, a first pre-cooler may be arranged in the first section of the ambient air line for precooling the ambient air compressed by the first ambient air compressor. The first pre-cooler is preferably arranged in a ram air duct and adapted to be flown through with ram air conducted through the ram air duct. In the first pre-cooler, the ambient air that was heated by the compression in the first ambient air compressor is cooled again to a desired lower temperature.

The aircraft air conditioning system may also comprise a first bypass line, which runs parallel to the first section of the ambient air line. A second valve is preferably arranged in the first bypass line, which second valve may be configured to control the flow of ambient air through the first bypass line. Ambient air that flows through the first bypass line is conducted past the first section of the ambient air line and consequently past the first ambient air compressor and the first pre-cooler. By appropriate control of the first valve arranged in the first section of the ambient air line and of the second valve arranged in the first bypass line, the ambient air may be

- 6 -

distributed as required to the first section of the ambient air line and the first bypass line, but in particular routed alternatively either through the first section of the ambient air line or the first bypass line.

5 In a preferred embodiment of the aircraft air conditioning system, the ambient air line also comprises a second section, which is arranged in particular downstream of the first section of the ambient air line and the first bypass line relative to the flow direction of the ambient air through the ambient air line. The ambient air fed to the second section of the ambient air line can consequently be conducted from the first
10 section of the ambient air line or the first bypass line into the second section of the ambient air line. In the second section of the ambient air line, a second ambient air compressor is preferably arranged for compressing the ambient air flowing through the second section of the ambient air line, wherein the ambient air fed to the second ambient air compressor may be ambient air precompressed in the first ambient air
15 compressor or ambient air that is routed to the second ambient air compressor untreated through the first bypass line. The second ambient air compressor, which is speed-regulated, for example, is preferably driven by a third electric motor. The second ambient air compressor may be controlled by the control device of the aircraft air conditioning system, for example, in such a way that it compresses the
20 ambient air flowing through the second section of the ambient air line to a pressure that is greater than the set cabin pressure in the aircraft cabin to be air conditioned. A third valve may be arranged in the second section of the ambient air line, which third valve may be configured to control the flow of ambient air through the second section of the ambient air line.

25 Although the second ambient air compressor compresses the ambient air flowing through the second section of the ambient air line to a pressure that is greater than the set cabin pressure in the aircraft cabin to be air conditioned, the operation of the first and second ambient air compressor is controlled such that the temperature of
30 the compressed ambient air does not exceed a maximum temperature of 160°C, for example. Due to this, insulation and ventilation of an installation space provided in an aircraft for the aircraft air conditioning system can be eliminated. This makes weight and cost savings possible.

35 The aircraft air conditioning system may also comprise a second bypass line, which runs parallel to the second section of the ambient air line. A fourth valve is preferably arranged in the second bypass line, which fourth valve may be configured to control

- 7 -

the flow of ambient air through the second bypass line. Ambient air flowing through the second bypass line is conducted past the second section of the ambient air line and consequently past the second ambient air compressor. By appropriate control of the third valve arranged in the second section of the ambient air line and of the fourth valve arranged in the second bypass line, the ambient air can be distributed as required to the second section of the ambient air line and the second bypass line, but in particular routed alternatively either through the second section of the ambient air line or the second bypass line.

The ambient air line of the aircraft air conditioning system also preferably comprises a third section, which is arranged in particular downstream of the second section of the ambient air line and the second bypass line relative to the flow direction of the ambient air through the ambient air line. The ambient air fed to the third section of the ambient air line can consequently be conducted from the second section of the ambient air line or via the second bypass line, circumventing the second section of the ambient air line, from the first section of the ambient air line to the third section of the ambient air line.

The third section of the ambient air line may be thermally coupled to the refrigerant circuit, preferably via the heat exchanger arranged in the refrigerant circuit of the refrigerating machine. The cooling of the ambient air in the ambient air line by heat transfer to the refrigerant circulating in the refrigerant circuit of the refrigerating machine accordingly takes place preferably during the flow through the third section of the ambient air line.

A second pre-cooler is preferably arranged in the third section of the ambient air line for precooling ambient air prior to the creation of the thermal coupling between the third section of the ambient air line and the refrigerant circuit of the refrigerating machine. The second pre-cooler is preferably arranged in a ram air duct and adapted to be flown through with ram air conducted through the ram air duct. For example, the first pre-cooler and the second pre-cooler may be arranged in a common ram air duct, wherein the first pre-cooler is then preferably positioned downstream of the second pre-cooler in the ram air duct relative to the flow direction of the ram air through the ram air duct.

The liquefier of the refrigerating machine may also be arranged in a ram air duct. The liquefier of the refrigerating machine, the first pre-cooler and the second pre-

- 8 -

cooler are preferably arranged in a common ram air duct. The aircraft air conditioning system then only has to have one ram air duct. The liquefier of the refrigerating machine is positioned preferably upstream of the second pre-cooler in the ram air duct relative to the flow direction of the ram air through the ram air duct.

5 Adequate cooling of the liquefier by the ram air flowing through the ram air duct is thereby guaranteed in all operating phases of the aircraft air conditioning system. In order to ensure a proper flow of ram air through the ram air duct even during ground operation of an aircraft equipped with the aircraft air conditioning system, a fan may also be arranged in the ram air duct to convey ram air through the ram air duct. The

10 fan is preferably driven by a fourth electric motor.

A trim air line preferably branches off from the third section of the ambient air line. The branch of the trim air line from the third section of the ambient air line lies, relative to the flow direction of the ambient air through the ambient air line,

15 preferably upstream of the thermal coupling of the third section of the ambient air line to the refrigerant circuit of the refrigerating machine and preferably also upstream of the second pre-cooler. It is ensured by this that the trim air is removed at a point of the third section of the ambient air line at which the ambient air flowing through the third section of the ambient air line has the maximum temperature. The

20 trim air flow through the trim air line may be controlled by a trim air valve arranged in the trim air line.

The ambient air line of the aircraft air conditioning system may also comprise a fourth section, which is arranged in particular downstream of the third section of the ambient air line relative to the flow direction of the ambient air through the ambient

25 air line. A water separation device, preferably an efficient high-pressure water separation device, may be arranged in the fourth section of the ambient air line. Furthermore, a turbine for expanding the ambient air flowing through the fourth section of the ambient air line may be arranged in the fourth section of the ambient

30 air line. Finally, a fifth valve may be arranged in the fourth section of the ambient air line, which fifth valve may be configured to control the ambient air flow through the fourth section of the ambient air line.

The water separation device arranged preferably upstream of the turbine in the

35 fourth section of the ambient air line relative to the flow direction of the ambient air through the ambient air line may comprise a water separator. When flowing through the water separator, the ambient air is dehumidified to such an extent that it is

ensured that not too much humidity is fed to the aircraft cabin to be air conditioned. Water separated in the water separator from the ambient air flowing through the fourth section of the ambient air line may be injected into the ram air duct via water injection. The water that partly evaporates there cools the ram air and increases the energy efficiency of the aircraft air conditioning system.

The water separation device may further comprise a reheater, which is arranged downstream of the water separator relative to the flow direction of the ambient air through the ambient air line, for heating the ambient air flowing through the fourth section of the ambient air line before it is fed to the turbine. The reheater may create a thermal coupling between the fourth section of the ambient air line and the second section of the ambient air line. In particular, the reheater may bring warm ambient air flowing through the second section of the ambient air line following its compression in the second ambient air compressor into thermal contact with the ambient air flowing through the fourth section of the ambient air line before it is fed to the turbine. Drops of water remaining in the ambient air flow after it has flowed through the water separator are evaporated in the reheater to protect the turbine from damage due to droplet impact or cavitation. The reheater also increases the output of the turbine.

In interaction with an ambient air compressor and in particular the second ambient air compressor arranged in the second section of the ambient air line, which compressor compresses the ambient air flowing through the second section of the ambient air line to a pressure that is greater than the set cabin pressure of the aircraft cabin to be air conditioned, the turbine arranged in the fourth section of the ambient air line makes possible the realisation of a cold air process in which the ambient air flowing through the ambient air line is first compressed and then expanded again and cooled in the process. Compressing the ambient air to a pressure lying above the set cabin pressure enables surplus water to be removed from the ambient air flow in the water separation device arranged in the fourth section of the ambient air line. By expanding the ambient air in the turbine, the ambient air is cooled to a desired low temperature before it is fed into the mixer of the aircraft air conditioning system. The turbine may be arranged on a common shaft with the second ambient air compressor arranged in the second section of the ambient air line.

- 10 -

In the aircraft air conditioning system, either exclusively the cold vapour process executed in the refrigerating machine or both the cold vapour process and the cold air process can accordingly be used as required to condition and cool the ambient air flowing through the ambient air line. Operation of the aircraft air conditioning system with exclusive use of the cold vapour process is suitable in particular in operating phases of the aircraft air conditioning system in which the ambient air flowing through the ambient air line only has a slight moisture content. This is the case, for example, during cruising flight of an aircraft equipped with the aircraft air conditioning system. Operation of the aircraft air conditioning system with use both of the cold vapour process and of the cold air process makes sense in particular if the ambient air flowing through the ambient air line has to be dehumidified before it is fed into the mixer of the aircraft air conditioning system, which is the case e.g. during ground operation and during climbing and descent of an aircraft equipped with the aircraft air conditioning system.

Finally, operation of the aircraft air conditioning system with exclusive use of the cold air process is also possible by switching off the refrigerating machine. This makes sense if the aircraft cabin is to be heated by the aircraft air conditioning system. Operation of the aircraft air conditioning system with exclusive use of the cold air process is also possible as an emergency mode in the event that the refrigerating machine fails. In such an emergency mode, both ambient air compressors may be to compress the ambient air flowing through the ambient air line, due to which it is possible to provide the aircraft cabin itself then with an adequate quantity of conditioned and cooled ambient air if one air conditioning unit fails completely in an aircraft air conditioning system equipped with two air conditioning units and in addition the refrigerating machine of the second air conditioning unit is no longer functional.

The aircraft air conditioning system may also comprise a third bypass line, which runs parallel to the fourth section of the ambient air line. A sixth valve is preferably arranged in the third bypass line, which sixth valve may be configured to control the flow of ambient air through the third bypass line. Ambient air that flows through the third bypass line is routed past the fourth section of the ambient air line and consequently past the water separation device and the turbine. By appropriate control of the fifth valve arranged in the fourth section of the ambient air line and of the sixth valve arranged in the third bypass line, the ambient air may be distributed as required to the fourth section of the ambient air line and the third bypass line, but

- 11 -

in particular routed alternatively either through the fourth section of the ambient air line or the third bypass line.

5 A control device of the aircraft air conditioning system is preferably configured to control the flow of ambient air through the ambient air line in such a way that the ambient air is first conducted alternatively either through the first section of the ambient air line or the first bypass line, the ambient air is then alternatively either conducted through the second section of the ambient air line or the second bypass line, the ambient air is then conducted through the third section of the ambient air
10 line, and the ambient air is then alternatively either conducted through the fourth section of the ambient air line or the third bypass line. The control device preferably controls the operation of the first to the sixth valve to this end.

15 The control device is configured in particular to control the flow of ambient air through the ambient air line in such a way that during ground operation of an aircraft equipped with the aircraft air conditioning system, the ambient air is conducted first through the first bypass line, then through the second section of the ambient air line, then through the third section of the ambient air line and finally through the fourth section of the ambient air line. During ground operation of an aircraft equipped with
20 the aircraft air conditioning system, the ambient air can thus be compressed upon flowing through the second ambient air compressor arranged in the second section of the ambient air line to a pressure lying above the set cabin pressure, which facilitates dehumidification of the ambient air in the water separation device provided in the fourth section of the ambient air line. The first ambient air compressor
25 arranged in the first section of the ambient air line is circumvented, on the other hand. The cooling of the ambient air is achieved both by the transfer of heat to the refrigerant circuit of the refrigerating machine and by expansion of the ambient air in the turbine arranged in the fourth section of the ambient air line.

30 The control device is preferably further configured to control the flow of ambient air through the ambient air line in such a way that during climbing or descent of an aircraft equipped with the aircraft air conditioning system, the ambient air is conducted first through the first section of the ambient air line, then through the second section of the ambient air line, then through the third section of the ambient
35 air line and finally through the fourth section of the ambient air line. During climbing or descent of an aircraft equipped with the aircraft air conditioning system, the first ambient air compressor arranged in the first section of the ambient air line and the

- 12 -

second ambient air compressor arranged in the second section of the ambient air line are thus connected in series in order to compress the ambient air flowing through the ambient air line to a pressure that facilitates dehumidification of the ambient air in the water separation device provided in the fourth section of the ambient air line even if the efficiency of the water separator decreases.

By connecting the ambient air compressors in series, both ambient air compressors can be operated in their optimal map range even in the event of high output requirements. The cooling of the ambient air takes place, as during ground operation, both by the transfer of heat to the refrigerant circuit of the refrigerating machine and by the expansion of the ambient air in the turbine arranged in the fourth section of the ambient air line.

Finally, the control device may be configured to control the flow of ambient air through the ambient air line in such a way that during cruising flight of an aircraft equipped with the aircraft air conditioning system, the ambient air is conducted first through the first section of the ambient air line, then through the second bypass line, then through the third section of the ambient air line and finally through the third bypass line. During cruising flight of an aircraft equipped with the aircraft air conditioning system, the ambient air flowing through the ambient air line is thus compressed exclusively by the first ambient air compressor arranged in the first section of the ambient air line to the set cabin pressure, since dehumidification of the very dry ambient air at cruising flight altitude of an aircraft is not necessary. The second ambient air compressor arranged in the second section of the ambient air line is accordingly also circumvented like the water separation device provided in the fourth section of the ambient air line and the turbine likewise provided in the fourth section of the ambient air line. The cooling of the ambient air takes place exclusively by the transfer of heat to the refrigerant circuit of the refrigerating machine.

In a method for operating an aircraft air conditioning system, ambient air is conducted through an ambient air line, which is connected to a mixer of the aircraft air conditioning system, to feed ambient air into the mixer. The ambient air flowing through the ambient air line is compressed in at least one ambient air compressor arranged in the ambient air line. A refrigerating machine is provided, which comprises a refrigerant circuit adapted to be flown through with a refrigerant as well as a refrigerant compressor arranged in the refrigerant circuit. The refrigerant circuit is thermally coupled to the ambient air line, in order to transfer heat from the

- 13 -

ambient air flowing through the ambient air line to the refrigerant circulating in the refrigerant circuit before the ambient air is fed into the mixer. The at least one ambient air compressor and/or the refrigerant compressor are driven by at least one electric motor.

5 The flow of ambient air through the ambient air line is preferably controlled in such a way that the ambient air is first conducted alternatively either through a first section of the ambient air line, in which a first ambient air compressor is arranged for compressing the ambient air flowing through the first section of the ambient air line,
10 or a first bypass line, the ambient air is then alternatively either conducted through a second section of the ambient air line, in which a second ambient air compressor is arranged for compressing the ambient air flowing through the second section of the ambient air line, or a second bypass line, the ambient air is then conducted through a third section of the ambient air line, which is thermally coupled to the refrigerant
15 circuit of the refrigerating machine, and the ambient air is then alternatively either conducted through a fourth section of the ambient air line, in which a water separation device and a turbine for expanding the ambient air flowing through the fourth section of the ambient air line are arranged, or a third bypass line.

20 In particular, the flow of ambient air through the ambient air line is controlled in such a way that during ground operation of an aircraft equipped with the aircraft air conditioning system, the ambient air is conducted first through the first bypass line, then through the second section of the ambient air line, then through the third section of the ambient air line and finally through the fourth section of the ambient
25 air line. During climbing or descent of an aircraft equipped with the aircraft air conditioning system, the flow of ambient air through the ambient air line is preferably controlled in such a way that the ambient air is conducted first through the first section of the ambient air line, then through the second section of the ambient air line, then through the third section of the ambient air line and finally through the
30 fourth section of the ambient air line. During cruising flight of an aircraft equipped with the aircraft air conditioning system, the flow of ambient air through the ambient air line is preferably controlled in such a way that the ambient air is conducted first through the first section of the ambient air line, then through the second bypass line, then through the third section of the ambient air line and finally through the third
35 bypass line.

A preferred embodiment of the invention is now explained in greater detail with reference to the enclosed schematic drawing, in which

Figure 1 shows an air conditioning system for air conditioning an aircraft cabin.

5 An aircraft air conditioning system 10 illustrated in figure 1 comprises an ambient air line 12 through which ambient air can flow and which is connected to a mixer 14 of the aircraft air conditioning system 10, in order to feed the mixer 14 with the ambient air taken from an aircraft's surroundings 15. In the mixer 14, the ambient air
10 from the ambient air line 12 is mixed with recirculation air taken from an aircraft cabin. The mixed air produced in the mixer 14 is finally used for air conditioning of the aircraft cabin.

15 The aircraft air conditioning system 10 is equipped with a refrigerating machine 16, which comprises a refrigerant circuit 18 through which a two-phase refrigerant flows, for example R134A ($\text{CH}_2\text{F}-\text{CF}_3$), CO_2 or R-245fa (1,1,1,3,3 pentafluoropropane), and a refrigerant compressor 20 arranged in the refrigerant circuit 18. The refrigerant compressor 20 is driven by a first electric motor 22. The refrigerant circuit 18 is thermally coupled to the ambient air line, in order to transfer heat from the ambient
20 air flowing through the ambient air line 12 to the refrigerant circulating in the refrigerant circuit 18 before the ambient air is fed into the mixer 14. Apart from the refrigerant compressor 20, a liquefier 24, a refrigerant collector 26, an expansion valve 28 and a heat exchanger 30 designed in the form of an evaporator, which thermally couples the refrigerant circuit 18 to the ambient air line 12, are arranged in
25 the refrigerant circuit 18.

The refrigerant circuit 18 of the refrigerating machine 16 is also thermally coupled to a recirculation air line 32, through which recirculation air flows and which is connected to the mixer 14 of the aircraft air conditioning system 10, in order to
30 transfer heat from the recirculation air flowing through the recirculation air line 32 to the refrigerant flowing through the refrigerant circuit 18. The thermal coupling between the refrigerant circuit 18 and the recirculation air line 32 is realised by a further heat exchanger 34 designed in the form of an evaporator, which is arranged in a connection line 36 branching off from the refrigerant collector 26 arranged in the
35 refrigerant circuit 18. The flow of refrigerant through the connection line 36 is controlled by a control valve 38 arranged in the connection line 36. Also arranged in the connection line 36, upstream of the further heat exchanger 34 relative to the

- 15 -

flow direction of the refrigerant through the refrigerant circuit 18, is another expansion valve 40. The pressure and the temperature of the refrigerant flowing through the connection line 36 can be adjusted as desired by the other expansion valve 40 before the refrigerant is conducted into the further heat exchanger 34.

5 In the aircraft air conditioning system 10, the refrigerating machine 16 is thus used not only to cool the ambient air flowing through the ambient air line 12, but also to cool recirculation air taken from the aircraft cabin to be air conditioned. The recirculation air can therefore be cooled before it is fed into the mixer 14 of the
10 aircraft air conditioning system 10 to the same low temperature as the ambient air flowing through the ambient air line 12. Cooling the ambient air to a temperature that lies below a desired set cabin feed air temperature by transferring heat to the refrigerant circulating in the refrigerant circuit 18 of the refrigerating machine 16 can consequently be eliminated. Furthermore, it also becomes possible to operate the
15 refrigerating machine 16 at relatively high minimum refrigerant temperatures.

The ambient air line 12 comprises a first section 12a, in which a first ambient air compressor 42 is arranged for compressing the ambient air flowing through the first section 12a of the ambient air line 12. The speed-controlled first ambient air
20 compressor 42 is driven by a second electric motor 44. The first ambient air compressor is controlled by a control device 46 of the aircraft air conditioning system 10 in such a way that it compresses the ambient air flowing through the first section 12a of the ambient air line 12 to the set cabin pressure in the aircraft cabin to be air conditioned. In the first section 12a of the ambient air line 12, a first valve 48 is also
25 arranged for controlling the flow of ambient air through the first section 12a of the ambient air line 12.

A first pre-cooler 50 for precooling of ambient air compressed by the first ambient air compressor 42 is also arranged in the first section 12a of the ambient air line 12. The
30 first pre-cooler 50 is arranged in a ram air duct 52 and ram air conducted through the ram air duct 52 flows through it in operation of the aircraft air conditioning system 10. In the first pre-cooler 50, the ambient air that was heated by compression in the first ambient air compressor 42 is cooled again to a desired lower temperature.

35 A first bypass line 54 runs parallel to the first section 12a of the ambient air line 12. A second valve 56 arranged in the first bypass line 54 is used to control the flow of

ambient air through the first bypass line 54. Ambient air that flows through the first bypass line 54 is conducted past the first section 12a of the ambient air line 12 and consequently past the first ambient air compressor 45 and the first pre-cooler 50.

5 The ambient air line 12 further comprises a second section 12b, which is arranged downstream of the first section 12a of the ambient air line 12 and the first bypass line 54 relative to the direction of flow of the ambient air through the ambient air line 10. The ambient air fed to the second section 12b of the ambient air line 12 can consequently be conducted from the first section 12a of the ambient air line 12 or
10 the first bypass line 54 to the second section 12b of the ambient air line 12. A second ambient air compressor 58 is arranged in the second section 12b of the ambient air line 12 for compressing the ambient air flowing through the second section 12b of the ambient air line 12, wherein ambient air precompressed by the first ambient air compressor 42 or untreated ambient air from the first bypass line 54 can be fed to
15 the second ambient air compressor 58. The speed-regulated second ambient air compressor 58 is driven by a third electric motor 60.

The second ambient air compressor 58 is controlled by the control device 46 of the aircraft air conditioning system 10 in such a way that it compresses the ambient air
20 flowing through the second section 12b of the ambient air line 12 to a pressure that is greater than the set cabin pressure in the aircraft cabin to be air conditioned. However, the operation of the first and the second ambient air compressor 42, 58, is controlled such that the temperature of the compressed ambient air does not exceed a maximum temperature of 160°C, for example. A third valve 62 arranged in the
25 second section 12b of the ambient air line 12 is used to control the flow of ambient air through the second section 12b of the ambient air line 12.

The aircraft air conditioning system 10 further comprises a second bypass line 64, which runs parallel to the second section 12b of the ambient air line 12. A fourth
30 valve 66 is arranged in the second bypass line 64, which fourth valve 66 controls the ambient air flow through the second bypass line 64. Ambient air which flows through the second bypass line 64 is conducted past the second section 12b of the ambient air line 12 and consequently past the second ambient air compressor 58.

35 The ambient air line 12 further comprises a third section 12c, which is arranged downstream of the second section 12b of the ambient air line and the second bypass line 64 relative to the flow direction of the ambient air through the ambient air line

- 17 -

12. The ambient air fed to the third section 12c of the ambient air line 12 can consequently be conducted from the second section 12b of the ambient air line 12 or via the second bypass line 64, circumventing the second section 12b of the ambient air line 12, from the first section 12a of the ambient air line 12 to the third section 12c of the ambient air line 12. The third section 12c of the ambient air line 12 is thermally coupled via the heat exchanger 30 arranged in the refrigerant circuit 18 of the refrigerating machine 16 to the refrigerant circuit 18. The cooling of the ambient air in the ambient air line 12 by heat transfer to the refrigerant circulating in the refrigerant circuit 18 of the refrigerating machine 16 accordingly takes place in the flow through the third section 12c of the ambient air line 12.

Arranged in the third section 12c of the ambient air line 12 is a second pre-cooler 68 for precooling ambient air prior to the creation of the thermal coupling between the third section 12c of the ambient air line 12 and the refrigerant circuit 18 of the refrigerating machine 16. The second pre-cooler 68 is arranged in the ram air duct 52 upstream of the first pre-cooler 50 relative to the flow direction of the ram air through the ram air duct and, like the first pre-cooler 50, ram air conducted through the ram air duct 52 flows through it in operation of the aircraft air conditioning system 10.

Apart from the first and the second pre-cooler 50, 68, the liquefier 24 of the refrigerating machine 16 is also arranged in the ram air duct 52, wherein the liquefier 24 is positioned upstream of the second pre-cooler 68 in the ram air duct 52 relative to the flow direction of the ram air through the ram air duct 52. In order to ensure a proper flow of ram air through the ram air duct 52 even during ground operation of an aircraft equipped with the aircraft air conditioning system 10, a fan 70 is also arranged in the ram air duct 52 to convey ram air through the ram air duct 52. The fan 70 is driven by a fourth electric motor 72.

A trim air line 74 branches off from the third section 12c of the ambient air line 12 upstream of the second pre-cooler 68 relative to the flow direction of the ambient air through the ambient air line 12. The trim air flow through the trim air line 74 is controlled by a trim air valve 76 arranged in the trim air line 74.

The ambient air line 12 of the aircraft air conditioning system 10 further comprises a fourth section 12d, which is arranged downstream of the third section 12c of the ambient air line 12 relative to the flow direction of the ambient air through the ambient air line 12. In the fourth section 12d of the ambient air line 12, a water

- 18 -

separation device 78 is arranged which comprises a water separator 80 and a reheater 82. On flowing through the water separator 80, the ambient air is dehumidified to such an extent that it is ensured that the aircraft cabin to be air conditioned is fed with not too much humidity. Water separated from the ambient air in the water separator 80 is conducted via a drainage line 84 into the ram air duct 52 and injected via a water injection nozzle 87 into the ram air duct 52. In the process the water partly evaporates and cools the ram air flowing through the ram air duct 52.

A turbine 86 for expanding the ambient air flowing through the fourth section 12d of the ambient air line 12 is also arranged in the fourth section 12d of the ambient air line 12. The turbine 86 is arranged on a common shaft with the second ambient air compressor 58 arranged in the second section 12b of the ambient air line 12. The reheater 82, which is arranged downstream of the water separator 80 relative to the flow direction of the ambient air through the ambient air line 12, is used to heat the ambient air flowing through the fourth section 12d of the ambient air line 12 before it is fed to the turbine 86 and creates a thermal coupling between the fourth section 12d of the ambient air line 12 and the second section 12b of the ambient air line 12. The reheater 82 thereby brings the warm ambient air flowing through the second section 12b of the ambient air line 12 following its compression in the second ambient air compressor 58 into thermal contact with the ambient air flowing through the fourth section 12d of the ambient air line 12 before it is fed to the turbine 86. In the reheater 82, drops of water remaining in the ambient air flow after it has flowed through the water separator 80 are evaporated to protect the turbine 86 from damage due to drop impact or cavitation. The reheater 82 also increases the output of the turbine 86.

Finally, a fifth valve 88 is arranged in the fourth section 12d of the ambient air line 12 for controlling the flow of ambient air through the fourth section 12d of the ambient air line 12.

The aircraft air conditioning system 10 further comprises a third bypass line 90, which runs parallel to the fourth section 12d of the ambient air line 12. A sixth valve 92 is arranged in the third bypass line 90 for controlling the ambient air flow through the third bypass line 90. Ambient air that flows through the third bypass line 90 is conducted past the fourth section 12d of the ambient air line 12 and consequently past the water separation device 78 and the turbine 86.

- 19 -

In interaction with an ambient air compressor 42, 58, in particular the second ambient air compressor 58, which compresses the ambient air flowing through the second section 12b of the ambient air line 12 to a pressure that is greater than the set cabin pressure in the aircraft cabin to be air conditioned, the turbine 86 arranged in the fourth section 12d of the ambient air line 12 facilitates the realisation of a cold air process in which the ambient air flowing through the ambient air line 12 is first compressed and then expanded again and cooled thereby. By compressing the ambient air to a pressure lying above the set cabin pressure, it becomes possible to remove excess water from the ambient air flow in the water separation device 78 arranged in the fourth section 12d of the ambient air line 12. By expanding the ambient air in the turbine 86, the ambient air is cooled to a desired low temperature before it is fed into the mixer of the aircraft air conditioning system.

In the aircraft air conditioning system, either exclusively the cold vapour process executed in the refrigerating machine 16 or both the cold vapour process and the cold air process can accordingly be used as required to condition and cool the ambient air flowing through the ambient air line 10. Operation of the aircraft air conditioning system with exclusive use of the cold vapour process is suitable in particular in operating phases of the aircraft air conditioning system 10 in which the ambient air flowing through the ambient air line only has a slight moisture content. Operation of the aircraft air conditioning system 10 with use both of the cold vapour process and of the cold air process makes sense in particular if the ambient air flowing through the ambient air line 10 has to be dehumidified before it is fed into the mixer 14 of the aircraft air conditioning system 10.

Finally, operation of the aircraft air conditioning system 10 with exclusive use of the cold air process is also possible by switching off the refrigerating machine 16. This makes sense if the aircraft cabin is to be heated by the aircraft air conditioning system 10. Operation of the aircraft air conditioning system 10 with exclusive use of the cold air process is also possible as an emergency mode in the event that the refrigerating machine 16 fails. In such an emergency mode, both ambient air compressors 42, 58 can be used to compress the ambient air flowing through the ambient air line 10, due to which it is possible then to provide the aircraft cabin with an adequate quantity of conditioned and cooled ambient air even if one air conditioning unit fails completely in an aircraft air conditioning system 10 equipped

- 20 -

with two air conditioning units and in addition the refrigeration apparatus of the second air conditioning unit is no longer functional.

The control device 46 controls the operation of the aircraft air conditioning system 10 in such a way that during ground operation of an aircraft equipped with the aircraft air conditioning system 10, the ambient air is conducted first through the first bypass line 54, then through the second section 12b of the ambient air line 12, then through the third section 12c of the ambient air line 12 and finally through the fourth section 12d of the ambient air line 12. During ground operation of an aircraft equipped with the aircraft air conditioning system 10, the ambient air is thus compressed upon flowing through the second ambient air compressor 58 to a pressure lying above the set cabin pressure, which facilitates dehumidification of the ambient air in the water separation device 78. The first ambient air compressor 42 is circumvented, on the other hand. The cooling of the ambient air is achieved both by the transfer of heat to the refrigerant circuit 18 of the refrigerating machine 16 and by expansion of the ambient air in the turbine 86.

During climbing or descent of an aircraft equipped with the aircraft air conditioning system 10, the control device 46 controls the flow of ambient air through the ambient air line 12 in such a way, on the other hand, that the ambient air is conducted first through the first section 12a of the ambient air line 12, then through the second section 12b of the ambient air line 12, then through the third section 12c of the ambient air line 12 and finally through the fourth section 12d of the ambient air line 12. During climbing or descent of an aircraft equipped with the aircraft air conditioning system 10, the first ambient air compressor 42 and the second ambient air compressor 58 are thus connected in series in order to compress the ambient air flowing through the ambient air line 12 to a pressure that facilitates dehumidification of the ambient air in the water separation device 78 even if the efficiency of the water separator 80 decreases. By connecting the ambient air compressors 42, 58 in series, both ambient air compressors 42, 58 can be operated in their optimal map range even in the event of high output requirements. The cooling of the ambient air takes place, as during ground operation, both by the transfer of heat to the refrigerant circuit 18 of the refrigerating machine 16 and by the expansion of the ambient air in the turbine 86.

During cruising flight of an aircraft equipped with the aircraft air conditioning system 10, the control device 46 controls the flow of ambient air through the ambient air line

- 21 -

12 finally in such a way that the ambient air is conducted first through the first section 12a of the ambient air line 12, then through the second bypass line 64, then through the third section 12c of the ambient air line 12 and finally through the third bypass line 90. During cruising flight of an aircraft equipped with the aircraft air conditioning system 10, the ambient air flowing through the ambient air line 12 is thus compressed exclusively by the first ambient air compressor 42 to the set cabin pressure, since dehumidification of the very dry ambient air at cruising flight altitude of an aircraft is not necessary. The second ambient air compressor 58 is accordingly also circumvented like the water separation device 78 and the turbine 86. The cooling of the ambient air takes place exclusively by the transfer of heat to the refrigerant circuit 18 of the refrigerating machine 16.

Claims

- 5 1. Aircraft air conditioning system (10) with:
- an ambient air line (12) which is adapted to be flown through with ambient air and which is connected to a mixer (14) of the aircraft air conditioning system (10), in order to feed the mixer (14) with ambient air,
 - at least one ambient air compressor (42, 58) arranged in the ambient air line (12)
 - 10 to compress the ambient air flowing through the ambient air line (12),
 - a refrigerating machine (16), which comprises a refrigerant circuit (18) adapted to be flown through with a refrigerant as well as a refrigerant compressor (20) arranged in the refrigerant circuit (18), wherein the refrigerant circuit (18) is thermally coupled to the ambient air line (12), in order to transfer heat from the ambient air flowing
 - 15 through the ambient air line (12) to the refrigerant circulating in the refrigerant circuit (18) before the ambient air is fed into the mixer (14),
 - characterised by at least one electric motor (22, 44, 60) for driving the at least one ambient air compressor (42, 58) and/or the refrigerant compressor (20).
- 20 2. Aircraft air conditioning system according to claim 1,
- characterised in that the refrigerant circulating in the refrigerant circuit (18) of the refrigerating machine (16) is a two-phase refrigerant and/or that a liquefier (24), a refrigerant collector (26), an expansion valve (28) and/or a heat exchanger (30), in particular an evaporator, which thermally couples the refrigerant circuit (18) to the
- 25 ambient air line (12), are arranged in the refrigerant circuit (18) of the refrigerating machine (16) apart from the refrigerant compressor (20) preferably driven by a first electric motor (22).
3. Aircraft air conditioning system according to claim 1 or 2,
- 30 characterised in that the refrigerant circuit (18) of the refrigerating machine (16) is thermally coupled to a recirculation air line (32) adapted to be flown through with recirculation air, in order to transfer heat from the recirculation air flowing through the recirculation air line (32) to the refrigerant circulating in the refrigerant circuit (18).
- 35 4. Aircraft air conditioning system according to claims 2 and 3,

characterised in that the refrigerant circuit (18) of the refrigerating machine (16) is thermally coupled to the recirculation air line (32) via a further heat exchanger (34), in particular a further evaporator, which is arranged in particular in a connection line (36) branching off from the refrigerant collector (26) arranged in the refrigerant circuit (18), wherein a control valve (38), which is configured to control the flow of refrigerant through the connection line (36), and/or another expansion valve (40) is/are preferably also arranged in the connection line (36).

5. Aircraft air conditioning system according to one of claims 1 to 4, characterised in that the ambient air line (12) comprises a first section (12a), in which a first ambient air compressor (42), in particular driven by a second electric motor (44) is arranged for compressing the ambient air flowing through the first section (12a) of the ambient air line (12), wherein in the first section (12a) of the ambient air line (12) a first valve (48) is preferably arranged, which is configured to control the flow of ambient air through the first section (12a) of the ambient air line (12), and wherein in the first section (12a) of the ambient air line (12) a first pre-cooler (50) is preferably also arranged for precooling ambient air compressed by the first ambient air compressor (42).

6. Aircraft air conditioning system according to claim 5, characterised by a first bypass line (54), which runs parallel to the first section (12a) of the ambient air line (12), wherein a second valve (56) is preferably arranged in the first bypass line (54), which second valve (56) is configured to control the flow of ambient air through the first bypass line (54).

7. Aircraft air conditioning system according to one of claims 1 to 5, characterised in that the ambient air line (12) comprises a second section (12b), in which a second ambient air compressor (58), in particular driven by a third electric motor (60), is arranged for compressing the ambient air flowing through the second section (12b) of the ambient air line (12), wherein in the second section (12b) of the ambient air line (12) a third valve (62) is preferably arranged, which is configured to control the flow of ambient air through the second section (12b) of the ambient air line (12).

8. Aircraft air conditioning system according to claim 7, characterised by a second bypass line (64), which runs parallel to the second section (12b) of the ambient air line (12), wherein a fourth valve (66) is preferably arranged

- 24 -

in the second bypass line (64), which fourth valve (66) is configured to control the flow of ambient air through the second bypass line (64).

9. Aircraft air conditioning system according to one of claims 1 to 8,
5 characterised in that the ambient air line (12) comprises a third section (12c), which is thermally coupled to the refrigerant circuit (18) of the refrigerating machine (16), wherein in the third section (12c) of the ambient air line (12) a second pre-cooler (68) is preferably arranged for precooling ambient air before the creation of the thermal coupling between the third section (12c) of the ambient air line (12) and the
10 refrigerant circuit (18), and wherein a trim air line (74) preferably branches off from the third section (12c) of the ambient air line (12).

10. Aircraft air conditioning system according to one of claims 1 to 9,
15 characterised in that the ambient air line (12) comprises a fourth section (12d), in which a water separation device (78) and a turbine (86) for expanding the ambient air flowing through the fourth section (12d) of the ambient air line (12) are arranged, wherein in the fourth section (12d) of the ambient air line (12) a fifth valve (88) is preferably arranged, which is configured to control the flow of ambient air through the fourth section (12d) of the ambient air line (12).

20 11. Aircraft air conditioning system according to claim 10, characterised by a third bypass line (90), which runs parallel to the fourth section (12d) of the ambient air line (12), wherein a sixth valve (92) is preferably arranged in the third bypass line (90), which sixth valve (92) is configured to control the flow
25 of ambient air through the third bypass line (90).

12. Aircraft air conditioning system according to one of claims 5 to 11,
characterised by a control device (46), which is configured to control the flow of ambient air through the ambient air line (12) in such a way that
30 - the ambient air is conducted first alternatively either through the first section (12a) of the ambient air line (12) or the first bypass line (54),
- the ambient air is then conducted alternatively either through the second section (12b) of the ambient air line (12) or the second bypass line (64),
- the ambient air is then conducted through the third section (12c) of the ambient air
35 line (12), and
- the ambient air is then conducted alternatively either through the fourth section (12d) of the ambient air line (12) or the third bypass line (90),

- 25 -

wherein the control device (46) is configured in particular to control the flow of ambient air through the ambient air line (12) in such a way that

- during ground operation of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first bypass line (54),
5 then through the second section (12b) of the ambient air line (12), then through the third section (12c) of the ambient air line (12) and finally through the fourth section (12d) of the ambient air line (12), and/or

- during climbing or descent of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first section (12a) of the
10 ambient air line (12), then through the second section (12b) of the ambient air line (12), then through the third section (12c) of the ambient air line (12) and finally through the fourth section (12d) of the ambient air line (12), and/or

- during cruising flight of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first section (12a) of the
15 ambient air line (12), then through the second bypass line (64), then through the third section (12c) of the ambient air line (12) and finally through the third bypass line (90).

13. Method for the operation of an aircraft air conditioning system

20 - conducting ambient air through an ambient air line (12), which is connected to a mixer (14) of the aircraft air conditioning system (10), in order to feed ambient air into the mixer (14),

- compressing the ambient air flowing through the ambient air line (12) in at least one ambient air compressor (42, 58) arranged in the ambient air line (12),

25 - providing a refrigerating machine (16), which comprises a refrigerant circuit (18) adapted to be flown through with a refrigerant as well as a refrigerant compressor (20) arranged in the refrigerant circuit (18),

- thermally coupling the refrigerant circuit (18) of the refrigerating machine (16) to the ambient air line (12), in order to transfer heat from the ambient air flowing
30 through the ambient air line (12) to the refrigerant circulating in the refrigerant circuit (18) before the ambient air is fed into the mixer (14),

characterised in that the at least one ambient air compressor (42, 54) and/or the refrigerant compressor (20) are driven by at least one electric motor (22, 44, 60).

35 14. Method according to claim 13,

characterised in that the flow of ambient air through the ambient air line (12) is controlled in such a way that

- 26 -

- the ambient air is conducted first alternatively either through a first section (12a) of the ambient air line (12), in which a first ambient air compressor (42) for compressing the air flowing through the first section (12a) of the ambient air line (12) is arranged, or a first bypass line (54),
- 5 - the ambient air is then conducted alternatively either through the second section (12b) of the ambient air line (12), in which a second ambient air compressor (54) for compressing the air flowing through the second section (12b) of the ambient air line (12) is arranged, or a second bypass line (64), and
- the ambient air is then conducted through a third section (12c) of the ambient air
10 line (12), which is thermally coupled to the refrigerant circuit (18) of the refrigerating machine (16), and
- the ambient air is then conducted alternatively either through a fourth section (12d) of the ambient air line (12), in which a water separation device (78) and a turbine (86) for expanding the ambient air flowing through the fourth section (12d)
15 of the ambient air line (12) are arranged, or a third bypass line (90).

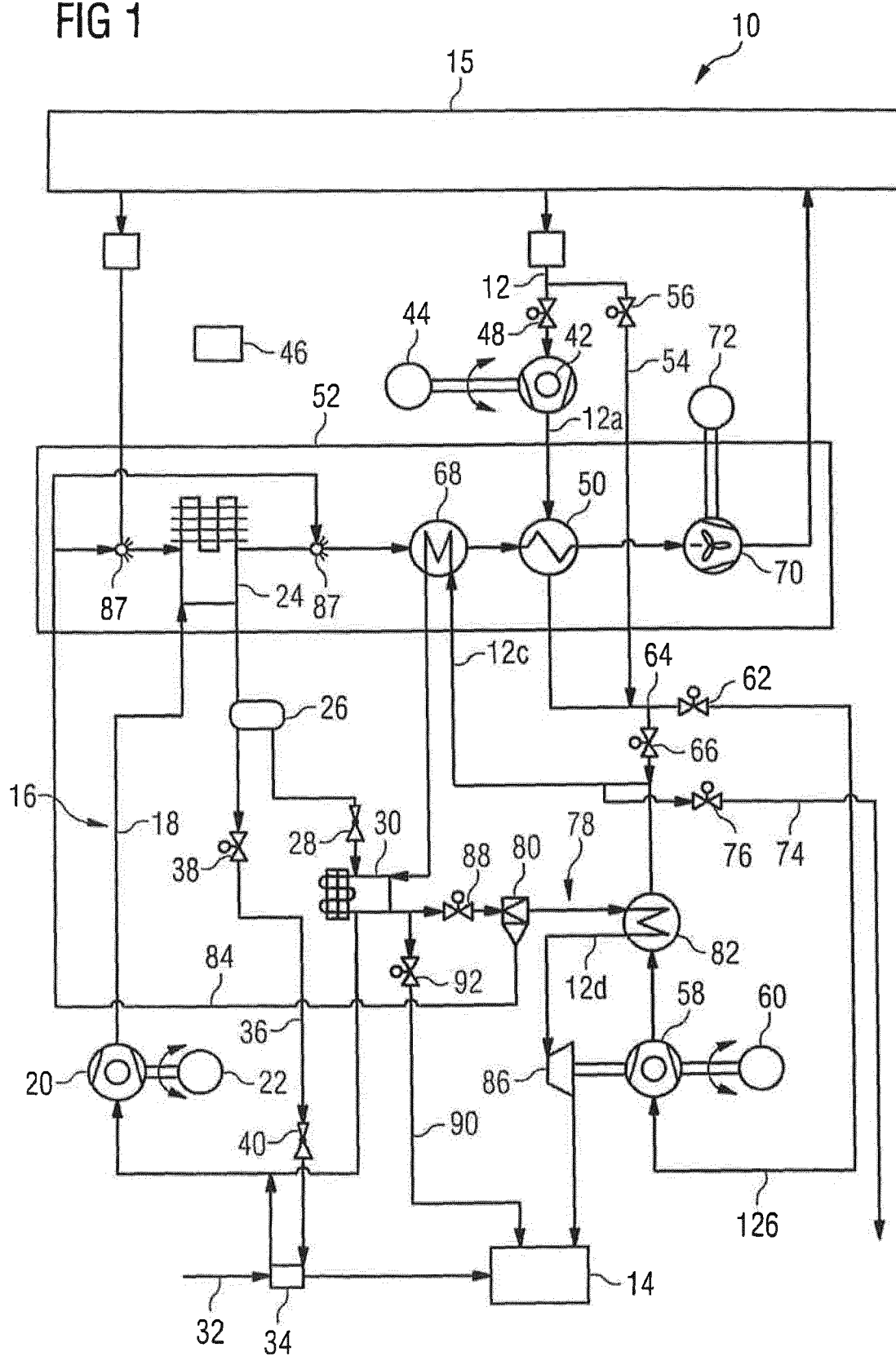
15. Method according to claim 14,

characterised in that the flow of ambient air through the ambient air line (12) is controlled in such a way that

- 20 - during ground operation of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first bypass line (54), then through the second section (12b) of the ambient air line (12), then through the third section (12c) of the ambient air line (12) and finally through the fourth section (12d) of the ambient air line (12), and/or
- 25 - during climbing or descent of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first section (12a) of the ambient air line (12), then through the second section (12b) of the ambient air line (12), then through the third section (12c) of the ambient air line (12) and finally through the fourth section (12d) of the ambient air line (12), and/or
- 30 - during cruising flight of an aircraft equipped with the aircraft air conditioning system (10), the ambient air is conducted first through the first section (12a) of the ambient air line (12), then through the second bypass line (64), then through the third section (12c) of the ambient air line (12) and finally through the third bypass line (90).

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FIG 1



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/059057

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64D13/06 B64D13/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B64D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 434 624 A (CRONIN MICHAEL J [US] ET AL) 6 March 1984 (1984-03-06) abstract; figures	1-11,13, 14
Y	EP 2 735 510 A1 (AIRBUS OPERATIONS GMBH [DE]) 28 May 2014 (2014-05-28) abstract; figures paragraphs [0015], [0031], [0035]	1-11,13, 14
A	EP 2 821 346 A1 (AIRBUS OPERATIONS GMBH [DE]) 7 January 2015 (2015-01-07) abstract; figures	1,13



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

4 July 2016

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Name and mailing address of the ISA/

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Nicol, Yann

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/059057

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4434624	A	06-03-1984	NONE
EP 2735510	A1	28-05-2014	NONE
EP 2821346	A1	07-01-2015	CN 104276287 A 14-01-2015
			EP 2821346 A1 07-01-2015
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