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# (54) HYPERLOOP ENVIRONMENTAL CONTROL SYSTEM

(57) An environmental control system for conditioning a cabin of a vehicle positioned in an enclosed air-evacuated environment includes a first inlet (24) for a first medium (A1), a second inlet (26) for a second medium (A2), and a thermodynamic device including a compressor and at least one turbine. The at least one turbine is fluidly coupled to and arranged downstream from the first and second inlet. A flow of the first medium (A1) and a first flow of the second medium (A2) are mixed to form a third medium at a first mixing point (M1) arranged downstream from the thermodynamic device relative to the flow of the first medium (A1). A dehumidification system (40) is fluidly coupled to the thermodynamic device and is arranged upstream from the at least one turbine. A regeneration heat exchanger (60) is fluidly coupled to and is downstream from the compressor. Heat is removed from the first medium (A1) at the regeneration heat exchanger (60).

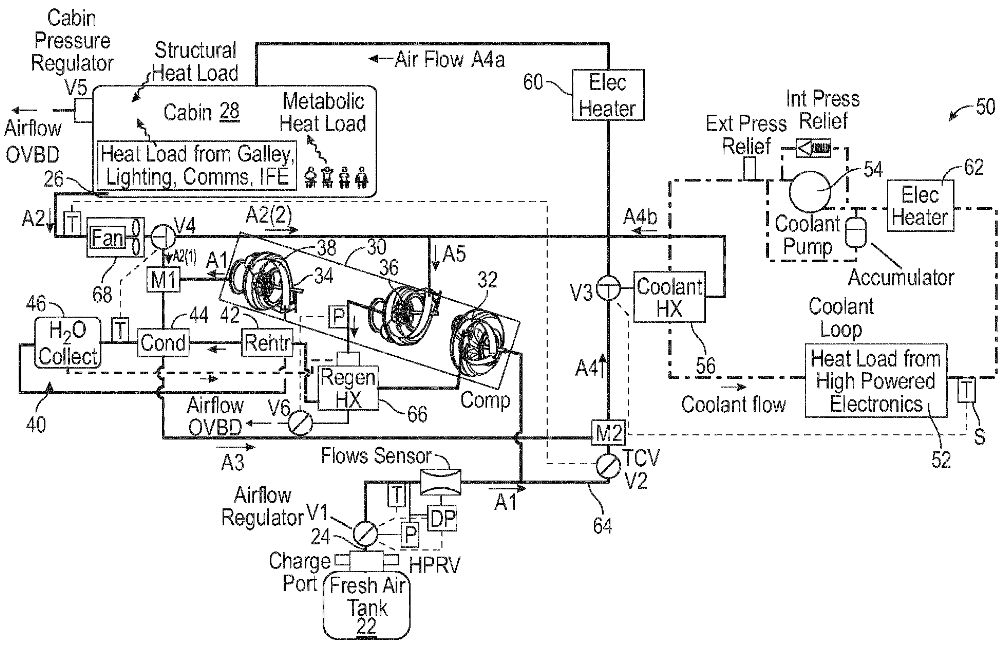


FIGURE 1



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## Description

BACKGROUND

**[0001]** The present disclosure relates to an environmental control system of a vehicle, and more particularly, to an environmental control system (ECS) for a vehicle travelling in a low pressure or zero pressure environment.

**[0002]** In general, a high-speed public transportation concept called the hyperloop has been proposed that can include a vehicle similar to a train car that travels inside of a tube. The air in the tube can be evacuated to a very deep vacuum, allowing the train to reach very high speeds without incurring the high-power demand that would otherwise be needed to overcome the high aerodynamic drag at normal atmospheric pressure. An air lock can permit passenger boarding and disembarking from the train station to the train without discharging the atmospheric air in the station into the vacuum in the tube.

**[0003]** As with similar transportation vehicles, environmental control of the occupied cabin is generally required to maintain adequate comfort and to provide heating, cooling and/or a continual supply of fresh air. Some typical methods used to provide air conditioning may not be conducive to this application. For example, many air conditioning systems exist which provide cool air to the cabin and on-board electronics may draw air from or ultimately exhaust the heat to the ambient atmosphere via convection heat transfer. When the ambient atmosphere is nonexistent, as in space applications, heat can be rejected to deep space via radiation heat transfer. In the case of the hyperloop, there is little to no atmosphere in the tube, so rejecting heat into the tube via convection may not be practical while maintaining a reasonably sized heat exchanger to reject the heat. Moreover, heat rejection via radiation may also not be practical, since unlike radiating to space, which is near absolute zero degrees in temperature, the walls of the tube can be warmer than inside the cabin when the outside ambient temperature is warm. Moreover, while the train is moving at high speed, the amount of available electrical power consumption is limited since power is generally supplied solely by on-board batteries that have a limited quantity of electrical energy.

BRIEF DESCRIPTION

**[0004]** According to an embodiment, an environmental control system for conditioning a cabin of a vehicle positioned in an enclosed air-evacuated environment includes a first inlet for receiving a first medium, a second inlet for receiving a second medium, and a thermodynamic device including a compressor and at least one turbine operably coupled by a shaft. The at least one turbine is fluidly coupled to and arranged downstream from the first inlet and the second inlet. A flow of the first medium and a first flow of the second medium are mixed to form a third medium at a first mixing point arranged downstream from the thermodynamic device relative to the flow of the first medium. A dehumidification system is fluidly coupled to the compressor and to the at least one turbine. The dehumidification system is arranged upstream from the at least one turbine. A regeneration heat exchanger is fluidly coupled to and is located downstream from an outlet of the compressor. Heat is removed from the first medium at the regeneration heat exchanger.

**[0005]** In addition to one or more of the features described above, or as an alternative, in further embodiments the compressor and the at least one turbine are arranged in series relative to the flow of the first medium.

**[0006]** In addition to one or more of the features described above, or as an alternative, in further embodiments the dehumidification system is arranged upstream from an inlet of the at least one turbine.

**[0007]** In addition to one or more of the features described above, or as an alternative, in further embodiments the dehumidification system includes a reheater, a condenser, and a water extractor arranged in series.

**[0008]** In addition to one or more of the features described above, or as an alternative, in further embodiments a bypass conduit is fluidly connected to the first inlet and is arranged in parallel with an inlet of the compressor. A valve is associated with the bypass conduit and is operable to control the flow of the first medium within the bypass conduit.

**[0009]** In addition to one or more of the features described above, or as an alternative, in further embodiments including a second mixing point fluidly coupled to the first mixing point and to the bypass conduit. A conditioned medium is output from the second mixing point.

**[0010]** In addition to one or more of the features described above, or as an alternative, in further embodiments a portion of the dehumidification system is positioned between and fluidly coupled the first mixing point and the second mixing point relative to a flow of the third medium.

**[0011]** In addition to one or more of the features described above, or as an alternative, in further embodiments a portion of the conditioned medium is provided to the regeneration heat exchanger of a cooling system.

**[0012]** In addition to one or more of the features described above, or as an alternative, in further embodiments the portion of the conditioned medium and a second flow of the second medium is mixed to form a mixed medium. The mixed medium being used to cool the first medium at the regeneration heat exchanger.

**[0013]** In addition to one or more of the features described above, or as an alternative, in further embodiments the mixed medium is provided to the at least one turbine of the thermodynamic device. The at least one turbine is fluidly coupled to and is arranged upstream from the regeneration heat exchanger.

**[0014]** In addition to one or more of the features described above, or as an alternative, in further embodiments the at least one turbine includes a first turbine and a second turbine. The second turbine is arranged downstream from and is in fluid communication with the compressor relative to the flow of the first medium. The second turbine is configured to receive the mixed medium.

**[0015]** In addition to one or more of the features described above, or as an alternative, in further embodiments at least one vessel of a pressurized first medium is located on board the vehicle.

**[0016]** In addition to one or more of the features described above, or as an alternative, in further embodiments the vehicle is a train.

**[0017]** According to an embodiment, a method of operating an environmental control system to condition a cabin of a vehicle positioned in an enclosed, air-evacuated tube includes compressing a first medium within a compressor of a thermodynamic device to form a compressed first medium, extracting energy from the compressed first medium at at least one turbine of the thermodynamic device to form an expanded first medium, forming a conditioned flow including the expanded first medium and a first flow of a second medium; extracting energy from a mixed medium at the at least one turbine of the thermodynamic device to form an expanded mixed medium; and cooling the compressed first medium using the expanded mixed medium. The extracted energy is used to drive the compressor.

**[0018]** In addition to one or more of the features described above, or as an alternative, in further embodiments drying the expanded first medium prior to extracting energy from the expanded first medium at the at least one turbine.

**[0019]** In addition to one or more of the features described above, or as an alternative, in further embodiments forming the conditioned flow includes mixing the first flow of the second medium with the expanded first medium to form a third medium and mixing the third medium with a flow of the first medium provided from a bypass conduit to form the conditioned medium. The flow of the first medium provided from the bypass conduit has bypassed the thermodynamic device.

**[0020]** In addition to one or more of the features described above, or as an alternative, in further embodiments providing a first portion of a flow of the conditioned medium to the cabin and providing a second portion of the flow of the conditioned medium to a cooling system.

**[0021]** In addition to one or more of the features described above, or as an alternative, in further embodiments providing the second portion of the flow of the conditioned medium to the cooling system includes removing heat from the cooling system.

**[0022]** In addition to one or more of the features described above, or as an alternative, in further embodiments includes mixing a portion of the conditioned medium with a second flow of the second medium to form the mixed medium.

**[0023]** In addition to one or more of the features described above, or as an alternative, in further embodiments providing the expanded mixed medium to a regeneration heat exchanger. Cooling the compressed first medium using the expanded mixed medium occurs at the regeneration heat exchanger.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]** The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

**[0025]** The Figure (Figure 1) is a schematic diagram of an example environmental control system (ECS) for a vehicle travelling within a hyperloop tube according to an embodiment.

## DETAILED DESCRIPTION

**[0026]** A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

**[0027]** The example embodiments disclosed herein are illustrative of a hyperloop environmental control system, and assemblies of the present disclosure and methods/techniques thereof. It should be understood, however, that the disclosed embodiments are merely examples of the present disclosure, which may be embodied in various forms. Therefore, details disclosed herein with reference to example hyperloop environmental control systems and associated processes/techniques of fabrication/assembly and use are not to be interpreted as limiting, but merely as the basis for teaching one skilled in the art how to make and use the systems/assemblies and/or alternative systems/assemblies of the present disclosure.

**[0028]** With reference now to the Figure, an example of an environmental control system 20 suitable for use with a vehicle movable within an enclosed air-evacuated environment is illustrated. The air-evacuated environment has a substantially zero-pressure or is a vacuum. In an embodiment, the vehicle is a car or train movable through a tube of a hyperloop system. As shown, the environmental control system 20 includes one or more vessels 22 located on-board the vehicle and configured to store a pressurized medium therein, such as high-pressure air for example. In an embodiment, the pressure of the medium within the at least one vessel 22 is between about 2000psi about 3000psi. The one or more vessels 22 may be considered a first fluid source and are fluidly coupled to a first inlet 24 of the environmental control system 20 to deliver a controlled flow of a first medium A1 to the environmental control system 20. The one or more vessels 22 may be filled, refilled, or replaced when the vehicle is stopped at a station or other facility.

**[0029]** The environmental control system 20 may additionally receive a flow of second medium A2 at a second inlet 26. In one embodiment, the second inlet 26 is operably coupled to a volume 28, such as the cabin or chamber of the vehicle in which the people are typically located. In such embodiments, the second medium A2 is cabin recirculation air. The environmental control system 20 is operable to provide a conditioned flow of one or both of the first medium A1 and the second medium A2 to the cabin 28 at standard atmospheric pressure of about 14.7 psi.

**[0030]** The environmental control system 20 may include at least one thermodynamic device 30, and in some embodiments, may include a plurality of thermodynamic devices. A thermodynamic device 30, as described herein, is a mechanical device that includes one or more components for performing thermodynamic work on a medium (e.g., extracts work from or applies work to the first medium A1 or the second medium A2 by raising and/or lowering pressure and by raising and/or lowering temperature). Examples of a thermodynamic device 30 include an air cycle machine, a two-wheel air cycle machine, a three-wheel air cycle machine, a four-wheel air cycle machine etc.

**[0031]** The single thermodynamic device 30 shown in the FIG. includes a compressor 32 and at least one turbine operably coupled by a shaft 34. In the illustrated, non-limiting embodiment, the thermodynamic device includes 30 a first turbine 36 and a second turbine 38. However, embodiments where the thermodynamic device 30 includes a single turbine, or alternatively, more than two turbines are also within the scope of the disclosure.

**[0032]** A compressor, such as compressor 32 for example, is a mechanical device configured to raise a pressure of a medium and can be driven by another mechanical device (e.g., a motor or a medium via a turbine). Examples of compressor types include centrifugal, diagonal or mixed-flow, axial-flow, reciprocating, ionic liquid piston, rotary screw, rotary vane, scroll, diaphragm, air bubble, etc. A turbine, such as first turbine 36 or second turbine 38 for example, is a mechanical device that expands a medium and extracts work therefrom (also referred to as extracting energy) to drive the compressor 32 via the shaft 34. The turbines 36, 38 may include a nozzle (not shown) configured to accelerate the medium supplied thereto for entry into an impeller of the turbine.

**[0033]** The environmental control system 20 may additionally include at least one dehumidification system 40. The dehumidification system 40 may be arranged in fluid communication with the first medium A1. In the illustrated, non-limiting embodiment, the dehumidification system includes a reheater 42, a condenser 44, and a water extractor or collector 46. The water extractor 46 is a mechanical device that performs a process of removing water from a medium.

**[0034]** In addition to providing a conditioned medium to the cabin 28, the environmental control system 20 may be used to transfer or redistribute heat between various systems onboard the vehicle. In an embodiment, the environmental control system 20 is operably coupled to a cooling system 50 used to cool high-powered electronics 52 located onboard the vehicle. As shown, a coolant, such as propylene glycol or ethylene glycol for example, is configured to circulate through the electronics 52 via a coolant pump 54, then is then provided to an electronics heat exchanger 56. In the illustrated, non-limiting embodiment, the environmental control system 20 is operably coupled to the cooling system 50 via the electronics heat exchanger 56. Accordingly, at the electronics heat exchanger 56, during operation of the environmental control system 20 in a "cooling mode" where the air provided to the cabin 28 is intended to reduce the temperature therein, heat is transferred from the coolant to the relatively cool medium of the environmental control system 20. Heat may also be transferred from the coolant to the relatively cool medium of the environmental control system 20 during operation in a "heating mode" where the air provided to the cabin is intended to increase the temperature therein.

**[0035]** The elements of the environmental control system 20 are connected via valves, tubes, pipes, conduits and the like. Valves (e.g., flow regulation device or mass flow valve) are devices that regulate, direct, and/or control a flow of a medium by opening, closing, or partially obstructing various passageways within the tubes, pipes, etc. of the system. Valves can be operated by actuators, such that flow rates of the medium in any portion of the environmental control system 20 can be regulated to a desired value. For instance, a first valve V1, such as an airflow regulator for example, is configured to control the flow of the first medium A1 provided to the environmental control system 20 via the first inlet 24. A second valve V2 may be operable to selectively divert the flow of the first medium A1 to bypass the substantially entire environmental control system 20, including the thermodynamic device 30 and the dehumidification system 40. A third valve can control the flow of a conditioned medium to both the cabin 28 and to the cooling system 50. In an embodiment, a fourth valve is operable to control the flow of the second medium mixed with the first medium and the control of the second medium used to power the compressor and/or as a heat sink. The environmental control system 20 may additionally include a V5 operable to exhaust a flow of medium from the cabin 28 or the environmental control system 20 overboard from the vehicle, such as into the atmosphere surrounding the exterior of the vehicle.

**[0036]** One or more of the valves V1-V5 may be configured to receive commands from an ECS controller (not shown), such as in response to feedback provided from one or more sensors S located in specific/desired locations in the environmental control system 20. Although various pressure and temperature sensors are illustrated, it should be appreciated that other sensors operable to monitor any suitable parameter of the environmental control system 20 and/or the cooling system 50 are within the scope of the disclosure.

**[0037]** Furthermore, a heater 60, such as an electrical heater for example, may also be provided for instances where the conditioned medium to be delivered to the cabin 28 needs to be heated. In such embodiments, the heater 60 may be arranged directly upstream from the cabin 28 relative to a flow of the conditioned medium. Alternatively, or in addition, a heater 62, such as an electrical heater, may be provided in the cooling system 50 for instances where the conditioned medium to be delivered to the cabin 28 needs additional heat beyond the load exhausted by the electronics 52.

**[0038]** In operation, a flow of first medium A1 at the first inlet 24, controlled by valve V1, is provided to the environmental control system 20. When the downstream valve V2 is in a first position, all or at least a portion of the flow of the first medium A1 is provided to the thermodynamic device 30, such as to the compressor 32 for example. However, when the valve V2 is in a second position, some or all of the flow of the first medium A1 is directed to a bypass conduit 64 in which the flow of the first medium A1 is configured to bypass the entire thermodynamic device 30.

**[0039]** The act of compressing the first medium A1 heats the first medium A1 and increases the pressure thereof. In an embodiment, a first inlet of a regeneration heat exchanger 66 is arranged directly downstream from the outlet of the compressor 32 and upstream from an inlet of a turbine of the thermodynamic device 30, such as the first turbine 36 for example. In such embodiments, the first medium A1 output from the thermodynamic device 30 is cooled within the regeneration heat exchanger 66.

**[0040]** The cool first medium A1 output from the regeneration heat exchanger 66 may then be provided to the dehumidification system 40, and more specifically to the reheater 42 and the condenser 44 in series. Within both the reheater 42 and the condenser 44, the flow of the first medium A1 is further cooled, causing moisture within the first medium A1 to condenser into a liquid. Upon exiting the condenser 44, the first medium A1 is provided to a water extractor 46, wherein the condenser water is removed from the first medium A1. From the outlet of the water extractor 46, the dry first medium A1 makes a second pass through the reheater 42. Accordingly, at the reheater 42, heat from the first medium A1 output from the regeneration heat exchanger 66 transfers to the first medium A1 output from the water extractor.

**[0041]** From the reheater 45, the warm dry first medium A1 is provided to an inlet of the second turbine 38, such as through a nozzle. The first medium A1 is expanded across the turbine and work is extracted therefrom. The extracted energy drives the compressor 32 via the shaft 34. Accordingly, the first medium A1 provided at the outlet of second turbine 38 is cooler and/or has a lower pressure than the first medium A1 provided to the inlet of the second turbine 38.

**[0042]** Simultaneously, a flow of second medium A2 is provided to the second inlet 26 of the environmental control system 20, such as from the cabin 28. Operation of a circulation fan 68 associated with the cabin 28 is configured not only to move the air within the cabin 28, but also to pump the second medium A2 toward the fourth valve V4. When the fourth valve V4 is in a first position, all, or at least a portion of the second medium A2 is directed to a first mixing point M1 where the second medium A2 is mixed with the first medium A1 to form a third medium A3. The portion of the flow of the second medium A2 directed towards the first mixing point M1 is also referred to herein as "a first flow A2(1) of the second medium." As shown, the first flow A2(1) of the second medium A2 may be configured to mix with the flow of the expanded first medium A1 from the outlet of the second turbine 38 of the thermodynamic device 30 at the first mixing point M1. The resulting third medium A3 may be configured to make at least one pass through the condenser 44, where the third medium A3 absorbs heat from the first medium A1 therein. The outlet of the condenser 44 may be fluidly coupled to a second mixing point M2. The second mixing point M2 is also fluidly coupled to the bypass conduit 64, such that in embodiments where a portion of the first medium A1 provided at the first inlet 24 is directed to the bypass conduit 64, this flow of first medium A1 mixes with the third medium A3 at the second mixing point M2 to form a conditioned medium A4. It should be appreciated that in embodiments where none of the first medium A1 is directed into the bypass conduit 64, the conditioned medium A4 output from the second mixing point M2 is simply the third medium A3.

**[0043]** Depending on the operating conditions of the environmental control system 20, in some embodiments, the conditioned medium A4 may be separated into a first portion of conditioned medium A4a used to condition the cabin 28 and a second portion of conditioned medium A4b for use by the cooling system 50. The amount of conditioned medium A4 provided to the cabin 28 and the cooling system 50, respectively, is controlled by the position of the valve V3. In an embodiment, the volume, or the rate at which the first portion of conditioned medium A4a is provided to the cabin 28 is equal to the volume or rate at which air is exhausted from the cabin 28 overboard, such as via operation of the cabin pressure regulator V5. As a result, the pressure within the cabin 28 remains generally constant.

**[0044]** When the fourth valve V4 is in a second position, some or all of the second medium A2 from the second inlet 26 is directed towards an inlet of the turbine, such as the first turbine 36. The flow of the second medium A2 directed towards the first turbine 36 is referred to herein as a "second flow A2(2) of the second medium." In an embodiment, the second flow of conditioned medium A4b, after being heated within the cooling system 50, is mixed with this second flow A2(2) of second medium to form a fifth or mixed medium A5 at a location upstream from the turbine inlet. It should be appreciated that embodiments where the mixed medium A5 includes only the second flow A2(2) of the second medium and embodiments where the mixed medium A5 includes only the second flow of conditioned medium A4b are within the scope of the disclosure based on the operating conditions of the environmental control system 20.

**[0045]** As shown, the warm mixed medium A5 is provided to a nozzle of the first turbine 36. Within the first turbine 36, the mixed medium A5 is expanded and work is extracted therefrom to form an expanded mixed medium A5. The work extracted from the mixed medium A5 in the first turbine 36 is used alone or in combination with the work extracted at the second turbine 38 to drive the compressor 32 to compress the first medium A1. Accordingly, the expanded mixed medium A5 provided at the outlet of the first turbine 36 is cooler and/or has a lower pressure than the mixed medium A5 provided to the inlet of the first turbine 36.

**[0046]** The outlet of the first turbine 36 may be fluidly connected to an inlet of the regeneration heat exchanger 66. Accordingly, the expanded mixed medium A5 may be used as a heat sink at the regeneration heat exchanger 66. Within the regeneration heat exchanger 66, heat transfers from the hot flow of compressed first medium A1 to the warm mixed medium A5. The resulting heated mixed medium A5 may then be exhausted overboard, into the air-evacuated atmosphere at the exterior of the vehicle.

**[0047]** An environmental control system 20 as illustrated and described here provides an efficient system for conditioning a cabin 28 of a vehicle travelling within low pressure environment or a vacuum.

**[0048]** The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

**[0049]** The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

**[0050]** While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made, and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

## Claims

1. An environmental control system for conditioning a cabin of a vehicle positioned in an enclosed air-evacuated environment, the environmental control system comprising:

    a first inlet (24) for receiving a first medium (A1);
    a second inlet (26) for receiving a second medium (A2);
    a thermodynamic device including a compressor and at least one turbine operably coupled by a shaft, the at least one turbine being fluidly coupled to and arranged downstream from the first inlet (24) and the second inlet (26);
    a first mixing point (M1) at which a flow of the first medium (A1) and a first flow of the second medium (A2) are mixed to form a third medium, the first mixing point (M1) being arranged downstream from the thermodynamic device relative to the flow of the first medium (A1);
    a dehumidification system (40) fluidly coupled to the compressor and to the at least one turbine, the dehumidification system (40) being arranged upstream from the at least one turbine; and
    a regeneration heat exchanger (60) fluidly coupled to and located downstream from an outlet of the compressor, wherein heat is removed from the first medium (A1) at the regeneration heat exchanger (60).

2. The environmental control system of claim 1, wherein the compressor and the at least one turbine are arranged in series relative to the flow of the first medium (A1).

3. The environmental control system of claim 1 or 2, wherein the dehumidification system (40) is arranged upstream from an inlet of the at least one turbine, and preferably wherein the dehumidification system (40) further comprises a reheater, a condenser, and a water extractor arranged in series.

4. The environmental control system of any preceding claim, further comprising:

    a bypass conduit fluidly connected to the first inlet (24), the bypass conduit being arranged in parallel with an inlet of the compressor; and
    a valve associated with the bypass conduit, the valve being operable to control the flow of the first medium (A1) within the bypass conduit.

5. The environmental control system of claim 4, further comprising a second mixing point fluidly coupled to the first mixing point (M1) and to the bypass conduit, wherein a conditioned medium is output from the

second mixing point.

6. The environmental control system of claim 5, wherein a portion of the dehumidification system (40) is positioned between and fluidly coupled the first mixing point (M1) and the second mixing point relative to a flow of the third medium.

7. The environmental control system of claim 5, wherein a portion of the conditioned medium is provided to the regeneration heat exchanger (60) of a cooling system, and preferably wherein the portion of the conditioned medium and a second flow of the second medium (A2) is mixed to form a mixed medium, the mixed medium being used to cool the first medium (A1) at the regeneration heat exchanger (60), and preferably wherein the mixed medium is provided to the at least one turbine of the thermodynamic device, the at least one turbine being fluidly coupled to and arranged upstream from the regeneration heat exchanger (60), and more preferably wherein the at least one turbine further comprises a first turbine and a second turbine, the second turbine being arranged downstream from and in fluid communication with the compressor relative to the flow of the first medium (A1), the second turbine being configured to receive the mixed medium.

8. The environmental control system of any preceding claim, further comprising at least one vessel of a pressurized first medium located on board the vehicle.

9. The environmental control system of any preceding claim, wherein the vehicle is a train.

10. A method of operating an environmental control system to condition a cabin of a vehicle positioned in an enclosed, air-evacuated tube, the method comprising:

compressing a first medium (A1) within a compressor of a thermodynamic device to form a compressed first medium (A1);
extracting energy from the compressed first medium (A1) at at least one turbine of the thermodynamic device to form an expanded first medium (A1), the extracted energy being used to drive the compressor;
forming a conditioned flow including the expanded first medium (A1) and a first flow of a second medium (A2);
extracting energy from a mixed medium at the at least one turbine of the thermodynamic device to form an expanded mixed medium; and
cooling the compressed first medium (A1) using the expanded mixed medium.

11. The method of claim 10, further comprising drying the expanded first medium (A1) prior to extracting energy from the expanded first medium (A1) at the at least one turbine.

12. The method of claim 10 or 11, wherein forming the conditioned flow further comprises:

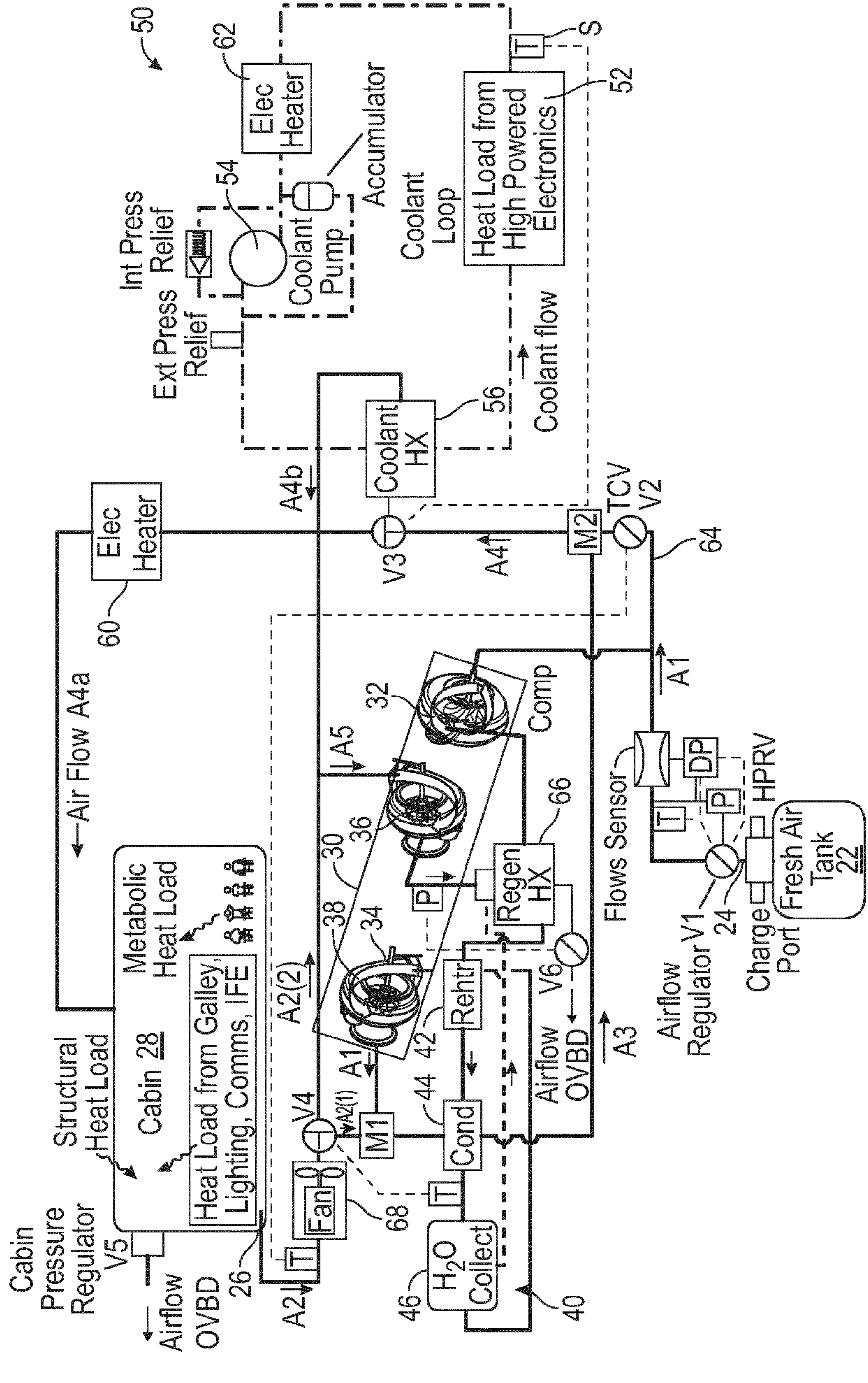
mixing the first flow of the second medium (A2) with the expanded first medium (A1) to form a third medium; and
mixing the third medium with a flow of the first medium (A1) provided from a bypass conduit to form the conditioned medium, the flow of the first medium (A1) provided from the bypass conduit having bypassed the thermodynamic device.

13. The method of claim 12, further comprising:

providing a first portion of a flow of the conditioned medium to the cabin; and
providing a second portion of the flow of the conditioned medium to a cooling system, and preferably wherein providing the second portion of the flow of the conditioned medium to the cooling system further comprises removing heat from the cooling system.

14. The method of claim 12, further comprising mixing a portion of the conditioned medium with a second flow of the second medium (A2) to form the mixed medium.

15. The method of any of claims 10-14, further comprising providing the expanded mixed medium to a regeneration heat exchanger (60), wherein cooling the compressed first medium (A1) using the expanded mixed medium occurs at the regeneration heat exchanger (60).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Elec Heater
54
Accumulator
Int Press Relief
Ext Press Relief
Coolant Pump
Coolant Loop
Heat Load from High Powered Electronics
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Coolant flow
56
Coolant HX
A4b
V3
A4
M2
TCV V2
64
Elec Heater
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Air Flow A4a
A5
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Comp
36
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P
Regen HX
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Flows Sensor
DP
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Fresh Air Tank 22
Charge Port
24
Airflow Regulator V1
A1
A3
Airflow OVBD
V6
Rehtr
42
A2(2)
A1
44
Cond
M1
V4
A2(1)
Metabolic Heat Load
Structural Heat Load
Cabin 28
Heat Load from Galley, Lighting, Comms, IFE
Fan
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46
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26
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Cabin Pressure Regulator V5
Airflow OVBD

FIGURE 1

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# EUROPEAN SEARCH REPORT

Application Number
EP 24 16 0189

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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