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(54) **HYDROGEN-COOLED ENVIRONMENTAL CONTROL SYSTEM**

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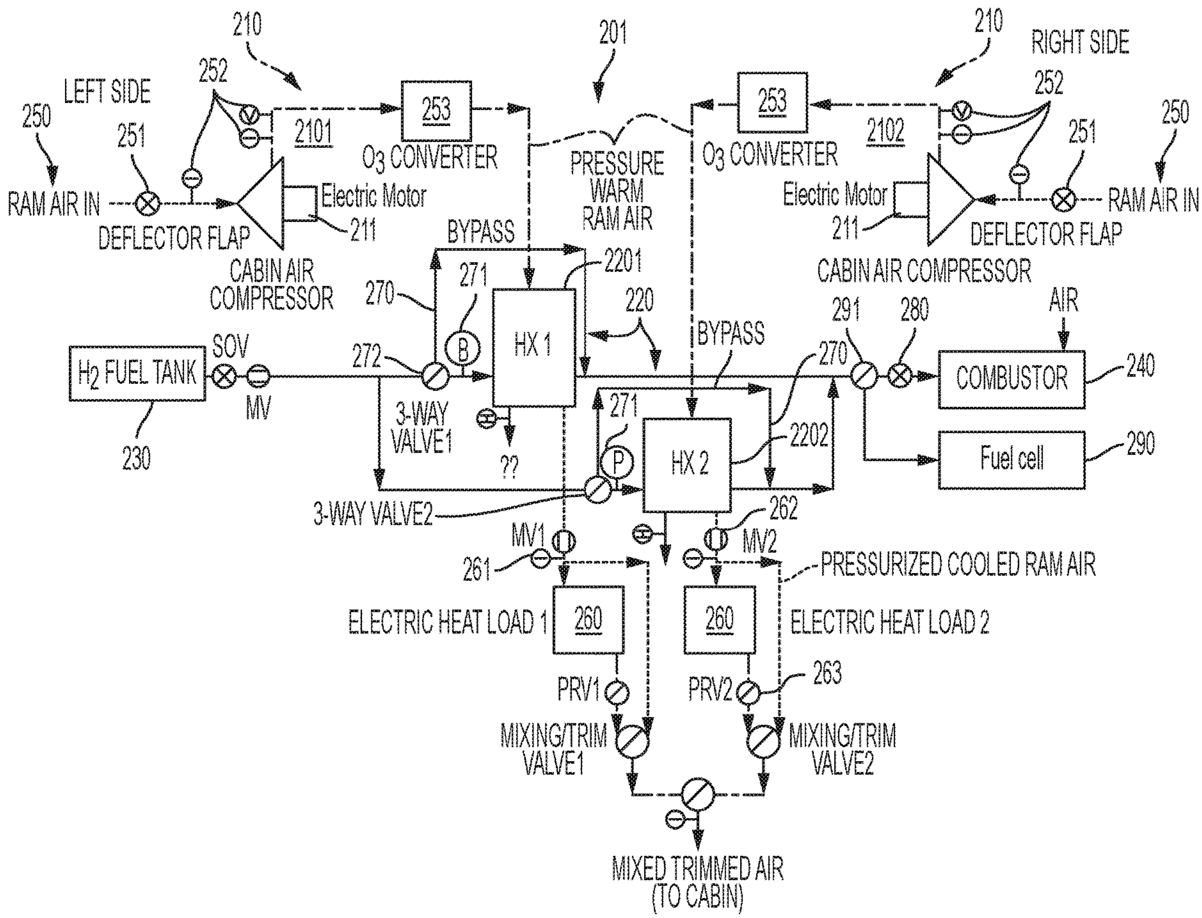
(57) **ABSTRACT**

A hydrogen-cooled environmental control system (ECS) is provided and includes a pressurizing system including an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin and a heat exchanger in which the pressurized warm RAM air is selectively cooled by hydrogen flown from a hydrogen fuel tank toward a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin.



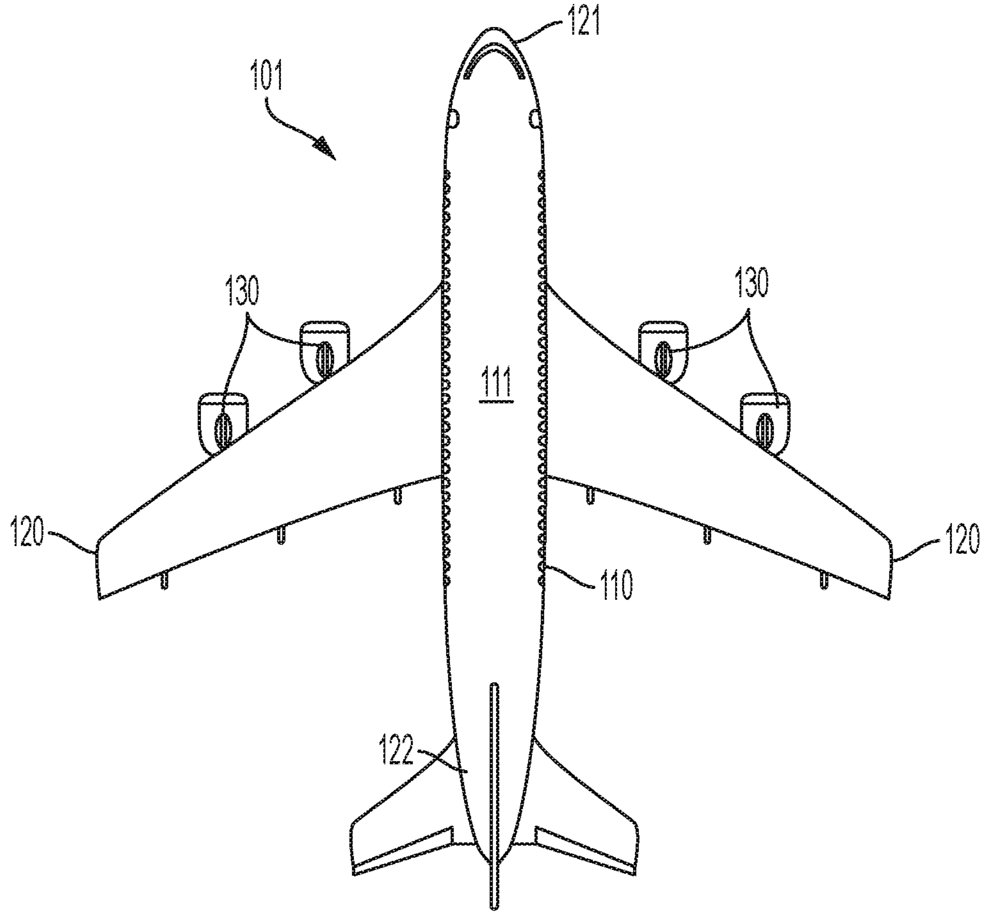
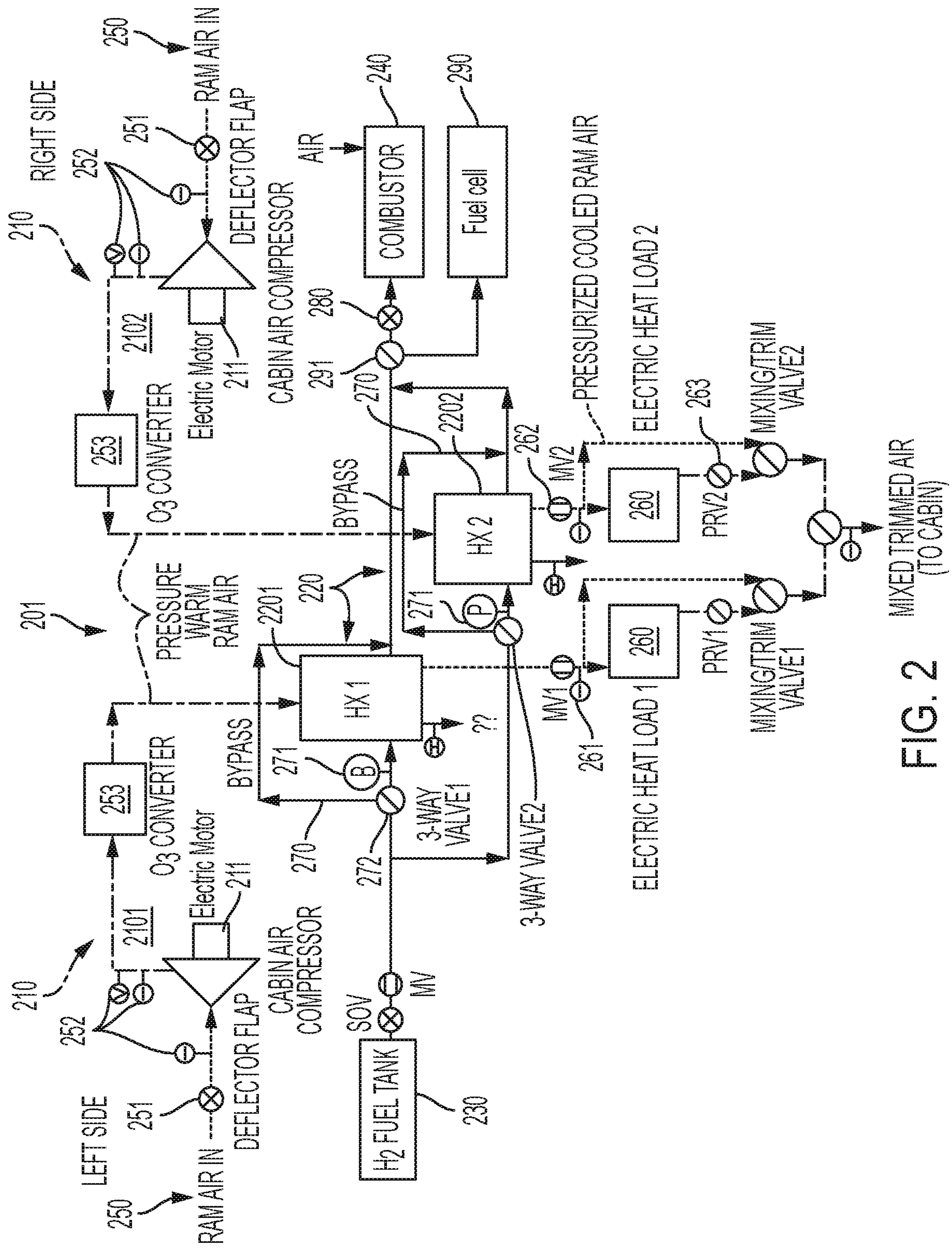


FIG. 1



RIGHT SIDE
LEFT SIDE
RAM AIR IN
250
251
252
210
201
220
DEFLECTOR FLAP
CABIN AIR COMPRESSOR
Electric Motor
211
2101
2102
253
O3 CONVERTER
PRESSURE WARM RAM AIR
AIR
COMBUSTOR
240
Fuel cell
290
280
291
270
271
272
2201
2202
BYPASS
HX 1
HX 2
B
P
H
??
3-WAY VALVE1
3-WAY VALVE2
H2 FUEL TANK
230
SOV
MV
MV1
MV2
261
262
263
260
ELECTRIC HEAT LOAD 1
ELECTRIC HEAT LOAD 2
PRESSURIZED COOLED RAM AIR
PRV1
PRV2
MIXING/TRIM VALVE1
MIXING/TRIM VALVE2
MIXED TRIMMED AIR (TO CABIN)

FIG. 2

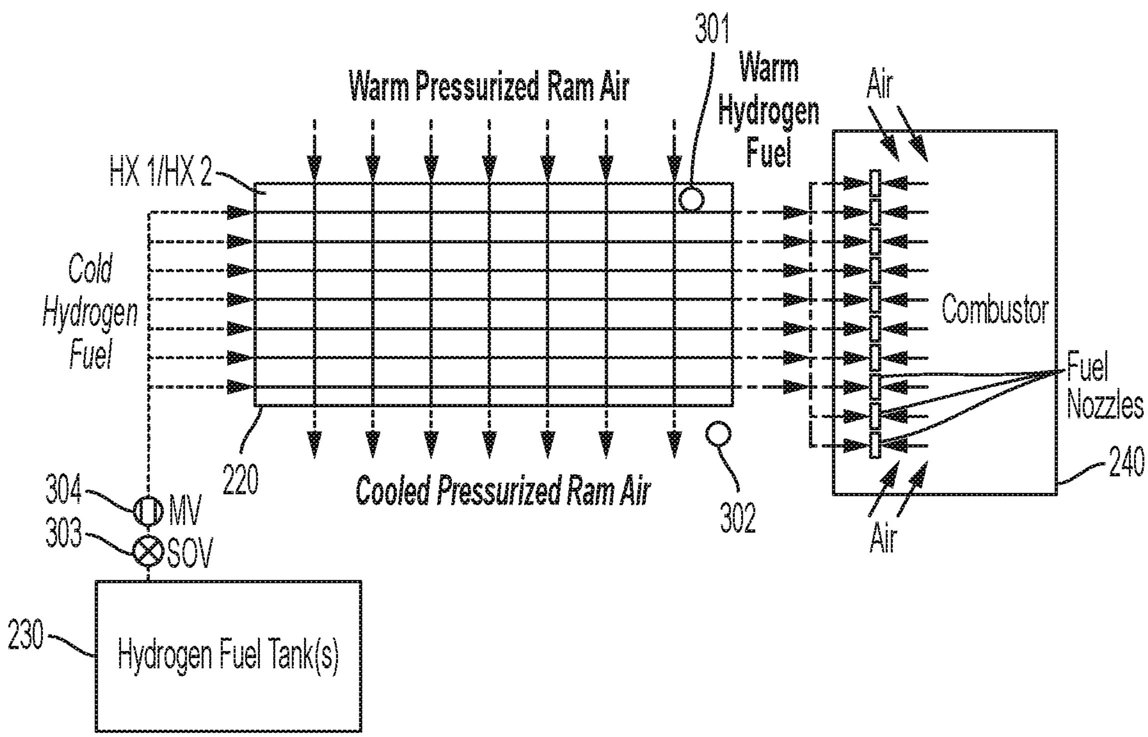

Warm Pressurized Ram Air
301
Warm Hydrogen Fuel
Air
HX 1/HX 2
Cold Hydrogen Fuel
Combustor
Fuel Nozzles
240
220
Cooled Pressurized Ram Air
302
Air
304
MV
303
SOV
230
Hydrogen Fuel Tank(s)

FIG. 3

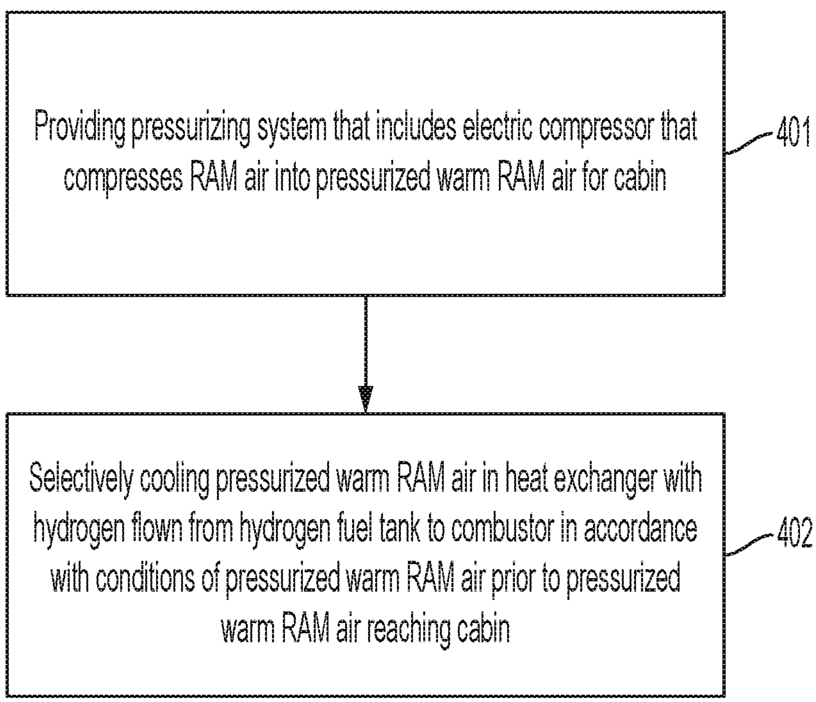

Providing pressurizing system that includes electric compressor that compresses RAM air into pressurized warm RAM air for cabin
401
Selectively cooling pressurized warm RAM air in heat exchanger with hydrogen flown from hydrogen fuel tank to combustor in accordance with conditions of pressurized warm RAM air prior to pressurized warm RAM air reaching cabin
402

FIG. 4

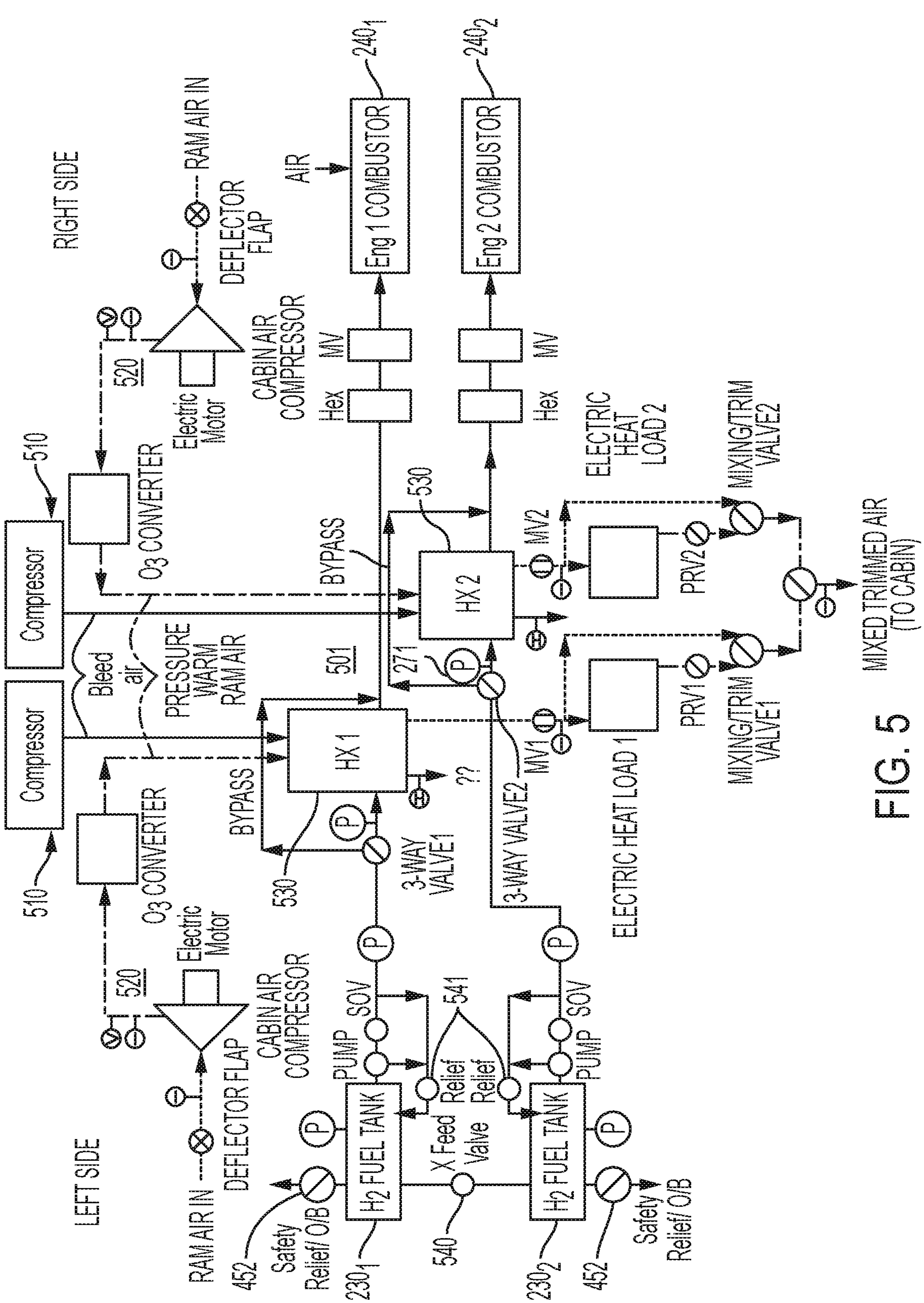

RIGHT SIDE
LEFT SIDE
RAM AIR IN
DEFLECTOR FLAP
CABIN AIR COMPRESSOR
Electric Motor
520
510
O3 CONVERTER
Compressor
Bleed air
PRESSURE WARM RAM AIR
BYPASS
HX 1
HX 2
501
530
271
??
3-WAY VALVE1
3-WAY VALVE2
MV1
MV2
ELECTRIC HEAT LOAD 1
ELECTRIC HEAT LOAD 2
PRV1
PRV2
MIXING/TRIM VALVE1
MIXING/TRIM VALVE2
MIXED TRIMMED AIR (TO CABIN)
Hex
MV
AIR
Eng 1 COMBUSTOR
Eng 2 COMBUSTOR
240₁
240₂
PUMP
SOV
Relief
541
X Feed Valve
H2 FUEL TANK
230₁
230₂
540
452
Safety Relief/ O/B
P

FIG. 5

HYDROGEN-COOLED ENVIRONMENTAL CONTROL SYSTEM

BACKGROUND

[0001] The following description relates to environmental control systems (ECSs) and, more specifically, to an integrated hydrogen-cooled ECS.

[0002] Consistent with modern advanced more electric aircraft/more electric engine (MEA/MEE) architectures, an integrated ECS can use electrically driven cabin air compressors to compress incoming ram air that enters the aircraft fuselage through opening scoops. This avoids wasteful bleeding of hot pressurized engine compressed air while improving overall thermodynamic performance. The pressurized warmed ram air is monitored with pressure sensors and temperature sensors. It flows through an ozone (O3) converter before it is flown to heat exchangers for cooling. A modulating deflector flap can be used to modulate the amount of ram air incoming to the inlet of each air compressor.

[0003] The use of dedicated heat exchangers for ECS can add weight while limiting available space for other needed equipment.

[0004] What is needed is a way to further integrate an ECS into modern MEA/MEE architecture. This is especially true for those cases where power is provided by on-board hydrogen.

BRIEF DESCRIPTION

[0005] According to an aspect of the disclosure, a hydrogen-cooled environmental control system (ECS) is provided and includes a pressurizing system including an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin and a heat exchanger in which the pressurized warm RAM air is selectively cooled by hydrogen flown from a hydrogen fuel tank toward a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin.

[0006] In accordance with additional or alternative embodiments, the cabin is an aircraft cabin of an aircraft, the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft and the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

[0007] In accordance with additional or alternative embodiments, the pressurizing system further includes a RAM air inlet including a controllable deflector flap, pressure and temperature sensors upstream and downstream from the electric compressor and an ozone converter interposed between the electric compressor and the heat exchanger.

[0008] In accordance with additional or alternative embodiments, the pressurizing system further includes an electric heat load heat exchanger interposed between the heat exchanger and the cabin and pressurized cooled RAM air from the heat exchanger is selectively used for cooling an electric heat load in the electric heat load heat exchanger in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

[0009] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a bypass line by which hydrogen flown from the hydrogen fuel tank toward the combustor bypasses the heat exchanger and a valve which is controllable to adjust an amount of the hydrogen that is permitted to flow along the bypass line.

[0010] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a fuel control valve upstream from the combustor to control an amount of the hydrogen that is permitted to flow into the combustor.

[0011] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a fuel cell in parallel with the combustor and a valve which is controllable to direct a first portion of the hydrogen toward the combustor and a second portion of the hydrogen toward the fuel cell.

[0012] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes an internal hydrogen leak sensor disposed within the heat exchanger to detect an internal hydrogen leak thereof, an external hydrogen leak sensor disposed at an exterior of the heat exchanger to detect an external hydrogen leak and a system to cut off a flow of the hydrogen into the heat exchanger in an event of the internal hydrogen leak and to cease the flow of the hydrogen in an event of the external hydrogen leak.

[0013] According to an aspect of the disclosure, a method of operating a hydrogen-cooled environmental control system (ECS) is provided and includes providing a pressurizing system including an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin and selectively cooling the pressurized warm RAM air in a heat exchanger with hydrogen flown from a hydrogen fuel tank to a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin.

[0014] In accordance with additional or alternative embodiments, the cabin is an aircraft cabin of an aircraft, the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft and the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

[0015] In accordance with additional or alternative embodiments, the method further includes selectively using pressurized cooled RAM air from the heat exchanger for cooling an electric heat load in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

[0016] In accordance with additional or alternative embodiments, the method further includes at least one of controllably bypassing a flow of the hydrogen around the heat exchanger, controlling an amount of the hydrogen that is permitted to flow into the combustor, cutting off a flow of the hydrogen into the heat exchanger in an event of a leak within the heat exchanger and ceasing the flow of the hydrogen in an event of a leak at an exterior of the heat exchanger.

[0017] According to an aspect of the disclosure, hydrogen-cooled environmental control system (ECS) is provided and includes a bleed air system providing pressurized warm bleed air for a cabin, a pressurizing system in parallel with the bleed air system and comprising an electric compressor that compresses RAM air into pressurized warm RAM air for the cabin and a heat exchanger in which at least one of the pressurized warm bleed air and the pressurized warm RAM air is selectively cooled by hydrogen flown from at least one hydrogen fuel tank toward at least one combustor in accordance with respective conditions of the pressurized warm bleed air and the pressurized warm RAM air prior to the pressurized warm bleed air and the pressurized warm RAM air reaching the cabin.

[0018] In accordance with additional or alternative embodiments, the cabin is an aircraft cabin of an aircraft, the bleed air system is provided as first and second bleed air systems for each side of the aircraft, the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft and the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

[0019] In accordance with additional or alternative embodiments, the pressurizing system further includes a RAM air inlet including a controllable deflector flap, pressure and temperature sensors upstream and downstream from the electric compressor and an ozone converter interposed between the electric compressor and the heat exchanger.

[0020] In accordance with additional or alternative embodiments, the pressurizing system further includes an electric heat load heat exchanger interposed between the heat exchanger and the cabin and pressurized cooled RAM air from the heat exchanger is selectively used for cooling an electric heat load in the electric heat load heat exchanger in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

[0021] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a bypass line by which hydrogen flown from the at least one hydrogen fuel tank toward the at least one combustor bypasses the heat exchanger and a valve which is controllable to adjust an amount of the hydrogen that is permitted to flow along the bypass line.

[0022] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a fuel control valve upstream from the at least one combustor to control an amount of the hydrogen that is permitted to flow into the at least one combustor.

[0023] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes a fuel cell in parallel with the at least one combustor and a valve which is controllable to direct a first portion of the hydrogen toward the at least one combustor and a second portion of the hydrogen toward the fuel cell.

[0024] In accordance with additional or alternative embodiments, the hydrogen-cooled ECS further includes an internal hydrogen leak sensor disposed within the heat exchanger to detect an internal hydrogen leak thereof, an external hydrogen leak sensor disposed at an exterior of the heat exchanger to detect an external hydrogen leak and a system to cut off a flow of the hydrogen into the heat exchanger in an event of the internal hydrogen leak and to cease the flow of the hydrogen in an event of the external hydrogen leak.

[0025] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The subject matter, which is regarded as the disclosure, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the disclosure are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0027] FIG. **1** is a top-down view of an aircraft in which an ECS is deployed in accordance with embodiments;

[0028] FIG. **2** is a schematic illustration of an ECS of the aircraft of FIG. **1** in accordance with embodiments;

[0029] FIG. **3** is a schematic diagram of heat exchangers of the ECS of FIG. **2** in accordance with embodiments;

[0030] FIG. **4** is a flow diagram illustrating a method of operating an ECS in accordance with embodiments; and

[0031] FIG. **5** is a schematic illustration of an ECS of the aircraft of FIG. **1** in accordance with further embodiments.

[0032] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

DETAILED DESCRIPTION

[0033] As will be described below, an ECS is integrated into modern MEA/MEE architecture, especially where power is provided by on-board hydrogen. On-board stored compressed liquefied hydrogen (H2) is used both as fuel (i.e., propellant) for a combustor as well as coolant media for pressurized warmed ram air to be used for the ECS and for cabin pressurization. In addition, the cold H2 can be used as a heat sink for various on-board heat loads. Such loads can be, but are not limited to, lubrication systems, hydraulic system, pneumatic system, various electric waste heat loads, etc.

[0034] With reference to FIG. **1**, an aircraft **101** is provided and includes a fuselage **110** which is formed to define a cabin **111** or an aircraft cabin in an interior thereof, aerodynamic features such as wings **120** that extend outwardly from the fuselage **110**, a nose **121** at a forward end of the fuselage **110** and a tail section **122** at a rear end of the fuselage **110**. The aircraft **101** further includes at least one engine **130** at either side of the aircraft **101** that generates power for flight and for other on-board powered features.

[0035] With reference to FIG. **2**, a hydrogen-cooled ECS **201** is provided for use with each side of the aircraft **101** of FIG. **1**. The hydrogen-cooled ECS **201** includes a pressurizing system **210** that can be provided as a first pressurizing system **2101** on a first side of the aircraft **101** and a second pressurizing system **2102** on a second side of the aircraft **101**. Each of the first pressurizing system **2101** and the second pressurizing system **2102** includes an electric compressor **211** that compresses RAM air into pressurized warm RAM air for the cabin **111** of FIG. **1**. The hydrogen-cooled ECS **201** further includes a heat exchanger **220** that can be provided as a first heat exchanger **2201** on the first side of the aircraft **101** and a second heat exchanger **2202** on the second side of the aircraft **101**.

[0036] Prior to the pressurized warm RAM air reaching the cabin **111**, the pressurized warm RAM air is selectively cooled in each of the first heat exchanger **2201** and the second heat exchanger **2202** by hydrogen (i.e., cold, liquid hydrogen) that is flown from a hydrogen fuel tank **230** toward a combustor **240**, which is configured to generate power for the at least one engine **130** (see FIG. **1**). The selective cooling of the pressurized warm air is executable in accordance with conditions of the pressurized warm RAM air, such as a pressure and a temperature of the pressurized warm air.

[0037] The following description will provide descriptions of additional features of the hydrogen-cooled ECS **201** of

FIG. **2**. Unless otherwise noted, these descriptions will refer to components of the hydrogen-cooled ECS **201** in the singular and it will be understood that they can each be provided on both sides of the aircraft **101**. This is done for clarity and brevity and should not be interpreted as limiting the description or the claims in any way.

[0038] The pressurizing system **210** (i.e., each of the first pressurizing system **2101** and the second pressurizing system **2102**) further includes a RAM air inlet **250** that includes a controllable deflector flap **251**, which is controllable to adjust an amount of RAM air that is permitted to enter into the RAM air inlet **250**, pressure and temperature sensors **252** operably disposed upstream and downstream from the electric compressor **211** to sense and thus determine the conditions of the pressurized warm RAM air and an ozone converter **253**. The ozone converter **253** is operably interposed between the electric compressor **211** and the heat exchanger **220** (i.e., the first heat exchanger **2201** and the second heat exchanger **2202**) to remove ozone from the pressurize warm RAM air.

[0039] The pressurizing system **210** (i.e., each of the first pressurizing system **2101** and the second pressurizing system **2102**) further includes an electric heat load heat exchanger **260**, additional sensors **261**, a metering valve **262** and a pressure relief valve **263**. The electric heat load heat exchanger **260** is operably interposed between the heat exchanger **220** (i.e., the first heat exchanger **2201** and the second heat exchanger **2202**) and the cabin **111** (see FIG. **1**). The additional sensors **261** can include temperature sensors to sense a temperature of pressurized cooled RAM air leaving the heat exchanger **220**. The metering valve **262** can be controlled in accordance with the readings of the additional sensors **261** to adjust an amount of the pressurized cooled RAM air that is permitted to leave the heat exchanger **220**. Within the electric heat load heat exchanger **260**, pressurized cooled RAM air from the heat exchanger **220** is selectively used for cooling an electric heat load in accordance with conditions of the pressurized cooled RAM air, as sensed by the additional sensors **261**, and the electric heat load. The pressure relief valve **263** is operably disposed to prevent a pressure within the electric heat load heat exchanger **260** from exceeding a predefined limit.

[0040] The pressurizing system **210** (i.e., each of the first pressurizing system **2101** and the second pressurizing system **2102**) further includes a bypass line **270** by which hydrogen flown from the hydrogen fuel tank **230** toward the combustor **240** bypasses the heat exchanger **220** (i.e., the first heat exchanger **2201** and the second heat exchanger **2202**), additional sensors **271** to sense a temperature and/or a pressure of the hydrogen, and a valve **272**, such as a three-way valve. The valve **272** is controllable in accordance with readings of the additional sensor **271** to adjust an amount of the hydrogen that is permitted to flow along the bypass line **270**.

[0041] The hydrogen-cooled ECS **201** can further include a fuel control valve **280**. The fuel control valve **280** is operably disposed upstream from the combustor **240** to control an amount of the hydrogen that is permitted to flow into the combustor **240**.

[0042] The hydrogen-cooled ECS **201** can further include a fuel cell **290**, which is disposed in parallel with the combustor **240**, and a valve **291**. The fuel cell **290** can be provided as a hydrogen-based fuel cell and can be configured to generate electric power for the aircraft **101** (see FIG. **1**). The valve **291** is operably disposed upstream from the combustor **240** and the fuel cell **290** and is controllable to direct a first portion of the hydrogen toward the combustor **240** and a second portion of the hydrogen toward the fuel cell **290**.

[0043] With reference to FIG. **3**, the heat exchanger **220** (i.e., the first heat exchanger **2201** and the second heat exchanger **2202**) is receptive of cold hydrogen fuel from the hydrogen fuel tank **230**. This cold hydrogen fuel removes heat from the warm pressurized RAM air as the cold hydrogen fuel and the warm pressurized RAM air move through the heat exchanger **220**. Subsequently, warm hydrogen fuel exits the heat exchanger **220** and proceeds to the combustor **240** while the cooled pressurized RAM air proceeds to the cabin **111** (see FIG. **1**).

[0044] As shown in FIG. **3**, the hydrogen-cooled ECS **201** can further include an internal hydrogen leak sensor **301**, which is disposed within the heat exchanger **220** to detect an internal hydrogen leak thereof, an external hydrogen leak sensor **302**, which is disposed at an exterior of the heat exchanger **220** to detect an external hydrogen leak, and a system of controllable valves (i.e., the valve **272** of FIG. **2**, a shut-off valve **303** and a metering valve **304**). The system of controllable valves can be configured to cut off a flow of the hydrogen into the heat exchanger **220** in an event of the internal hydrogen leak sensed by the internal hydrogen leak sensor **301** and to cease the flow of the hydrogen from the hydrogen fuel tank **230** in an event of the external hydrogen leak sensed by the external hydrogen leak sensor **302**.

[0045] With reference to FIG. **4**, a method of operating a hydrogen-cooled ECS, such as the hydrogen-cooled ECS **201** described above, is provided. The method includes providing a pressurizing system that includes an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin (block **401**) and selectively cooling the pressurized warm RAM air in a heat exchanger with hydrogen flown from a hydrogen fuel tank to a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin (block **402**). As above, the cabin can be an aircraft cabin of an aircraft, the pressurizing system can be provided as first and second pressurizing systems for each side of the aircraft and the heat exchanger can be provided as first and second heat exchangers for each side of the aircraft.

[0046] The method can further include selectively using pressurized cooled RAM air from the heat exchanger for cooling an electric heat load in accordance with conditions of the pressurized cooled RAM air and the electric heat load and at least one of controllably bypassing a flow of the hydrogen around the heat exchanger, controlling an amount of the hydrogen that is permitted to flow into the combustor, cutting off a flow of the hydrogen into the heat exchanger in an event of a leak within the heat exchanger and ceasing the flow of the hydrogen in an event of a leak at an exterior of the heat exchanger.

[0047] With reference to FIG. **5**, a hydrogen-cooled ECS **501** is provided and is generally similar to the hydrogen-cooled ECS of FIGS. **1-3** except that the hydrogen-cooled ECS **501** includes a bleed air system **510**, a pressurizing system **520** and a heat exchanger **530**. The bleed air system **510** provides pressurized warm bleed air for cabin **111** from a compressor of the at least one engine **130** (see FIG. **1**). The pressurizing system **520** is provided in parallel with the bleed air system **510** and is otherwise similar to the pressurizing system **210** of FIG. **2**. At least one of the pressurized warm bleed air and the pressurized warm RAM air is selectively cooled within the heat exchanger **530** by hydrogen flown from the hydrogen fuel tank **230** toward the combustor **240** in accordance with respective conditions of the pressurized warm bleed air and the pressurized warm RAM air prior to the pressurized warm bleed air and the pressurized warm RAM air reaching the cabin **111** (see FIG. **1**).

[0048] FIG. **5** also illustrates that the hydrogen-cooled ECS **501** can include multiple combustors (i.e., engine 1 combustor $\mathbf{240}_1$ and engine 2 combustor $\mathbf{240}_2$) and that the hydrogen fuel tank **230** can be provided as first and second hydrogen fuel tanks $\mathbf{230}_1$ and $\mathbf{230}_2$ where hydrogen fuel tank $\mathbf{230}_1$ fuels the engine 1 combustor $\mathbf{240}_1$ via a pump, a solenoid valve, a heat exchanger and a metering valve and the hydrogen fuel tank $\mathbf{230}_2$ fuels the engine 2 combustor $\mathbf{240}_2$ via a pump, a solenoid valve, a heat exchanger and a metering valve. In these or other cases, the first and second hydrogen fuel tanks $\mathbf{230}_1$ and $\mathbf{230}_2$ can be coupled via feed valve **540** and each can be provided with multiple safety/relief valves **541** and **542**.

[0049] It is to be understood that the various features described above with reference to FIG. **5** can be included in at least the embodiments of FIG. **2** and vice versa. For example, the fuel cell **290** of FIG. **2** can be provided as multiple fuel cells that are respectively disposed in parallel with engine 1 combustor $\mathbf{240}_1$ and with engine 2 combustor $\mathbf{240}_2$.

[0050] Technical effects and benefits of the present disclosure are the utilization of H2 as both fuel and coolant for various on-board waste heat loads. Heated vaporized H2 fuel “keeps” (i.e., absorbs) waste heat and transfers it during combustion processes, thus improving overall thermodynamic cycle of the system. The present disclosure also provides for the use of H2 as a coolant sink for pressurized warm ram air (for ECS), utilization of avionics waste heat for warming up of pressurized cooled ram air (for ECS), the use of double-walled buffer geometry for the H2 flow inside the hydrogen-to-air heat exchangers, safety detection H2 molecule sensors for accidental H2 leak inside either heat exchanger (HX1/HX2) with a bypass for H2 around heat exchangers, a simple and lightweight and robust integrated ECS and an integrated control system that is fully integrated with on-board aircraft computers and electronic engine controllers (EECs) to fully optimize thermal management system performance.

[0051] While the disclosure is provided in detail in connection with only a limited number of embodiments, it should be readily understood that the disclosure is not limited to such disclosed embodiments. Rather, the disclosure can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the disclosure. Additionally, while various embodiments of the disclosure have been described, it is to be understood that the exemplary embodiment(s) may include only some of the described exemplary aspects. Accordingly, the disclosure is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

What is claimed is:

1. A hydrogen-cooled environmental control system (ECS), comprising:

a pressurizing system comprising an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin; and

a heat exchanger in which the pressurized warm RAM air is selectively cooled by hydrogen flown from a hydrogen fuel tank toward a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin.

2. The hydrogen-cooled ECS according to claim **1**, wherein:

the cabin is an aircraft cabin of an aircraft,

the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft, and

the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

3. The hydrogen-cooled ECS according to claim **1**, wherein the pressurizing system further comprises:

a RAM air inlet comprising a controllable deflector flap;

pressure and temperature sensors upstream and downstream from the electric compressor; and

an ozone converter interposed between the electric compressor and the heat exchanger.

4. The hydrogen-cooled EC according to claim **1**, wherein:

the pressurizing system further comprises an electric heat load heat exchanger interposed between the heat exchanger and the cabin, and

pressurized cooled RAM air from the heat exchanger is selectively used for cooling an electric heat load in the electric heat load heat exchanger in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

5. The hydrogen-cooled ECS according to claim **1**, further comprising:

a bypass line by which hydrogen flown from the hydrogen fuel tank toward the combustor bypasses the heat exchanger; and

a valve which is controllable to adjust an amount of the hydrogen that is permitted to flow along the bypass line.

6. The hydrogen-cooled ECS according to claim **1**, further comprising a fuel control valve upstream from the combustor to control an amount of the hydrogen that is permitted to flow into the combustor.

7. The hydrogen-cooled ECS according to claim **1**, further comprising:

a fuel cell in parallel with the combustor; and

a valve which is controllable to direct a first portion of the hydrogen toward the combustor and a second portion of the hydrogen toward the fuel cell.

8. The hydrogen-cooled ECS according to claim **1**, further comprising:

an internal hydrogen leak sensor disposed within the heat exchanger to detect an internal hydrogen leak thereof;

an external hydrogen leak sensor disposed at an exterior of the heat exchanger to detect an external hydrogen leak; and

a system to cut off a flow of the hydrogen into the heat exchanger in an event of the internal hydrogen leak and to cease the flow of the hydrogen in an event of the external hydrogen leak.

9. A method of operating a hydrogen-cooled environmental control system (ECS), the method comprising:

providing a pressurizing system comprising an electric compressor that compresses RAM air into pressurized warm RAM air for a cabin; and

selectively cooling the pressurized warm RAM air in a heat exchanger with hydrogen flown from a hydrogen fuel tank to a combustor in accordance with conditions of the pressurized warm RAM air prior to the pressurized warm RAM air reaching the cabin.

10. The method according to claim **9**, wherein:

the cabin is an aircraft cabin of an aircraft,

the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft, and

the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

11. The method according to claim **9**, further comprising selectively using pressurized cooled RAM air from the heat exchanger for cooling an electric heat load in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

12. The method according to claim **9**, further comprising at least one of:

controllably bypassing a flow of the hydrogen around the heat exchanger;

controlling an amount of the hydrogen that is permitted to flow into the combustor;

cutting off a flow of the hydrogen into the heat exchanger in an event of a leak within the heat exchanger; and

ceasing the flow of the hydrogen in an event of a leak at an exterior of the heat exchanger.

13. A hydrogen-cooled environmental control system (ECS), comprising:

a bleed air system providing pressurized warm bleed air for a cabin;

a pressurizing system in parallel with the bleed air system and comprising an electric compressor that compresses RAM air into pressurized warm RAM air for the cabin; and

a heat exchanger in which at least one of the pressurized warm bleed air and the pressurized warm RAM air is selectively cooled by hydrogen flown from at least one hydrogen fuel tank toward at least one combustor in accordance with respective conditions of the pressurized warm bleed air and the pressurized warm RAM air prior to the pressurized warm bleed air and the pressurized warm RAM air reaching the cabin.

14. The hydrogen-cooled ECS according to claim **13**, wherein:

the cabin is an aircraft cabin of an aircraft,

the bleed air system is provided as first and second bleed air systems for each side of the aircraft;

the pressurizing system is provided as first and second pressurizing systems for each side of the aircraft, and

the heat exchanger is provided as first and second heat exchangers for each side of the aircraft.

15. The hydrogen-cooled ECS according to claim **13**, wherein the pressurizing system further comprises:

a RAM air inlet comprising a controllable deflector flap;

pressure and temperature sensors upstream and downstream from the electric compressor; and

an ozone converter interposed between the electric compressor and the heat exchanger.

16. The hydrogen-cooled ECS according to claim **13**, wherein:

the pressurizing system further comprises an electric heat load heat exchanger interposed between the heat exchanger and the cabin, and

pressurized cooled RAM air from the heat exchanger is selectively used for cooling an electric heat load in the electric heat load heat exchanger in accordance with conditions of the pressurized cooled RAM air and the electric heat load.

17. The hydrogen-cooled ECS according to claim **13**, further comprising:

a bypass line by which hydrogen flown from the at least one hydrogen fuel tank toward the at least one combustor bypasses the heat exchanger; and

a valve which is controllable to adjust an amount of the hydrogen that is permitted to flow along the bypass line.

18. The hydrogen-cooled ECS according to claim **13**, further comprising a fuel control valve upstream from the at least one combustor to control an amount of the hydrogen that is permitted to flow into the at least one combustor.

19. The hydrogen-cooled ECS according to claim **13**, further comprising:

a fuel cell in parallel with the at least one combustor; and

a valve which is controllable to direct a first portion of the hydrogen toward the at least one combustor and a second portion of the hydrogen toward the fuel cell.

20. The hydrogen-cooled ECS according to claim **13**, further comprising:

an internal hydrogen leak sensor disposed within the heat exchanger to detect an internal hydrogen leak thereof;

an external hydrogen leak sensor disposed at an exterior of the heat exchanger to detect an external hydrogen leak; and

a system to cut off a flow of the hydrogen into the heat exchanger in an event of the internal hydrogen leak and to cease the flow of the hydrogen in an event of the external hydrogen leak.

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