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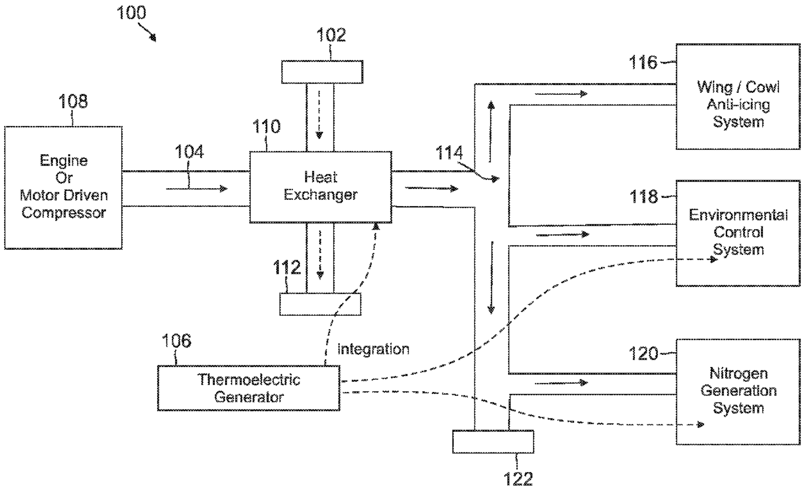

FIG. 1

(57) Abstract: A device for producing electrical power. A thermoelectric device is coupled to an aircraft bleed system for generating electrical power using temperature differentials between ram air and bleed air.

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THERMOELECTRIC GENERATOR ON AN AIRCRAFT BLEED SYSTEM

TECHNICAL FIELD

This application generally relates to power systems, and, more particularly, to the integration of a thermoelectric device into an aircraft bleed system for producing electrical power while reducing ram air intake.

BACKGROUND

Bleed air may be used by many systems on an aircraft. For example, in a nitrogen generation system, bleed air may be used for nitrogen generation to inert fuel tanks to remove potential hazardous situations arising from combustible combinations of oxygen, fuel vapors, and ignition sources. In operation, the nitrogen generation system may extracts bleed air and cool its temperature through the use of outside ram air within an air-to-air exchanger. In the process of cooling the temperature of the bleed air, waste heat may be expelled with exhaust. The regulated air may then be supplied to a pressurized chamber, such as an air separation stage, where the air exhaust from the pressurized chamber or air drawn out of the pressurized chamber may be separated into nitrogen enriched air and oxygen enriched air. The nitrogen enriched air may thereafter be supplied to the fuel tanks.

Ram air may be utilized as a coolant within the air-to-air heat exchanger. The aircraft may utilize ram air induction systems to capture air as a function of the movement of the aircraft. The air may be channeled through conduits which lead to the air-to-air heat exchanger. If the ram air induction is designed properly, when the aircraft is in motion, sufficient airflow may be provided to the air-to-air heat exchanger as the aircraft travels through an air medium. Air drag may directly affect the amount of energy used to overcome the amount of resistance produced by the air drag. Consequently, when more ram air is taken in for cooling bleed air, the greater the drag placed upon the aircraft.

Therefore, a need exists to provide a system and method to overcome the above issues.

SUMMARY

A device for producing electric power comprising: a bleed air system; and a thermoelectric device coupled to the bleed air system for generating the electrical power using temperature differentials between ram air and bleed air.

A method for generating power on an aircraft bleed system comprising: receiving ram air; receiving bleed air; and directing the ram air and the bleed air through a thermoelectric generator coupled to the aircraft bleed system for generating electrical energy

A system comprising a thermoelectric device with an air-to-air heat exchanger receiving bleed air, wherein said thermoelectric device produces electrical energy from a temperature difference between said bleed air and ram air while cooling said bleed air

The features, functions, and advantages can be achieved independently in various embodiments of the disclosure or may be combined in yet other embodiments.

BRIEF DESCRIPTION OF DRAWINGS

The novel features believed to be characteristic of the application are set forth in the appended claims. In the descriptions that follow, like parts are marked throughout the specification and drawings with the same numerals, respectively. The drawing figures are not necessarily drawn to scale and certain figures may be shown in exaggerated or generalized form in the interest of clarity and conciseness. The application itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will be best understood by reference to the following detailed description of illustrative embodiments when read in conjunction with the accompanying drawings, wherein:

FIGURE 1 shows a typical aircraft bleed system;

FIGURE 2 depicts a block diagram representing components of an illustrative nitrogen generation system having a thermoelectric generator with air-to-air heat exchanger in accordance with one embodiment;

FIGURE 3 is a pictorial representation of the thermoelectric generator with air-to-air heat exchanger receiving bleed air and ram air to produce electrical energy in accordance with one embodiment;

FIGURE 4 depicts a thermoelectric generator in accordance with one embodiment;

FIGURE 5 shows the integration of the thermoelectric generator with air-to-air heat exchanger into an existing nitrogen generation system in accordance with one embodiment;

FIGURE 6 provides a block diagram illustrating a system architecture splitting the thermoelectric generator and air-to-air heat exchanger in accordance with one embodiment;

FIGURE 6A depicts the integration of exemplary channeling within the nitrogen generation system in accordance with one embodiment;

FIGURE 7 provides a block diagram illustrating a system architecture splitting the thermoelectric generator and air-to-air heat exchanger in accordance with one embodiment;

FIGURE 7A depicts the integration of exemplary channeling within the nitrogen generation system in accordance with one embodiment;

FIGURE 8A depicts a front view of a thermoelectric generator in accordance with one embodiment;

FIGURE 8B is a sectional side view of the thermoelectric generator in accordance with one embodiment;

FIGURE 9A is a sectional side view of a thermoelectric generator in accordance with one embodiment; and

FIGURE 9B depicts a typical operation of the thermoelectric generator in accordance with one embodiment.

DESCRIPTION OF THE APPLICATION

The description set forth below in connection with the appended drawings is intended as a description of presently preferred embodiments of the application and is not intended to represent the only forms in which the present application may be constructed and/or utilized. The description sets forth the functions and the sequence of steps for constructing and operating the application in connection with the illustrated embodiments. It is to be understood, however, that the same or equivalent functions and sequences may be accomplished by different embodiments that are also intended to be encompassed within the spirit and scope of this application.

FIGURE 1 shows a typical aircraft bleed air system **100** where multiple locations may be identified for thermoelectric generation. As provided for, the aircraft bleed system **100** may typically include an engine or motor driven compressor **108**, a heat exchanger **110**, an exhaust **112**, a bleed air duct **114**, a wing/cowl anti-icing system **116**, an environmental control system **118**, a nitrogen generation system **120**, and other systems **122** that may use bleed air **104**. A thermoelectric generator **106** may be integrated into a variety of locations or positions within the aircraft bleed system **100** to generate electrical energy such as, but not limited to, the heat-exchanger **110**, the environmental control system **118**, and nitrogen generation system **120**. The thermoelectric generator **106** may be coupled to other locations within or outside the aircraft bleed system **100** where a temperature difference may be maintained so that the electrical energy may be produced. One skilled in the relevant art will appreciate that the aircraft bleed system **100** may contain more or less components and that **FIGURE 1** is provided for illustrative purposes.

Bleed air **104** may contain thermal energy that may be converted into useful electrical energy through thermoelectric generator **106**. As shown, the bleed air **104** may come from the engine or motor driven compressor **108**. Typically, the engine may produce bleed air **104** within its gas turbines generally after the compressor stage and before fuel is injected into the burners. Bleed air **104** often has a high pressure and high temperature.

The heat-exchanger **110** may receive the bleed air **104** from the engine or motor driven compressor **108**. The heat-exchanger **110** may then cool the bleed air **104** typically using ram air **102**. As shown, the thermoelectric generator **106** may be implemented within the heat-exchanger **110** to generate electrical energy taking advantage of the hot bleed air **104** and the cool ram air **102** provided thereto.

Generally, however, the bleed air **104** may be provided to systems within the aircraft bleed system **100** using bleed air duct **114**. In one embodiment, the bleed air **104** may be provided to the wing/cowl anti-icing system **116**. Typically, the wing/cowl anti-icing system **116** may be designed to keep atmospheric ice from accumulating on flight surfaces, which may ultimately disrupt the airflow across the wings or other surface.

The bleed air **104** may also be circulated to an environmental control system **118**, which takes the bleed air **104** and delivers it to the cabin in the form of fresh, conditioned air for on-board passengers. In one embodiment, the bleed air **104** from the heat-exchanger **110** is further cooled down through an air conditioner on the environmental control system **118**.

As described above, the thermoelectric generator **106** may be placed on the environmental control system **118** to generate electrical energy. Using bleed air **104** and ram air **102** channeled through the bleed air duct **114**, electrical energy may be produced using the temperature gradient between the two.

The bleed air **104** may also be provided to other systems **122**, some which may produce electrical energy using a thermoelectric generator **106**. In one example, the bleed air **104** may be used for pneumatic actuators. One skilled in the relevant art will appreciate that there are a variety of applications in which bleed air **104** may be used and those presented above do not limit the scope of the present application.

As shown, and in one embodiment, the bleed air **104** may be provided to a nitrogen generation system **120**. **FIGURE 2** depict an exemplary block diagram representing typical components of an illustrative nitrogen generation system **120** having a thermoelectric generator with air-to-air heat exchanger **200** in accordance with one embodiment. While the current embodiment depicts the thermoelectric generator coupled to the air-to-air heat exchanger, multiple configurations may be used. For example, the thermoelectric generator may be outside of the nitrogen generation system **120** and separate from the air-to-air heat exchanger. In one alternative, conduits may be positioned so that the thermoelectric generator **106** does not have to be near the air-to-air heat exchanger. Details regarding the thermoelectric generator **106** with the air-to-air heat exchanger **200** will be described in more detail below.

The nitrogen generation system **120** may receive ram air **102** and bleed air **104** and expel ram air exhaust **206** and provide nitrogen enriched air to a fuel tank **208**. Ram air **102** generally refers to cool or cold air and is represented by longer lines as shown in **FIGURE 2**. Ram air **102**, in one embodiment, may be taken at 0 °C or below 0 °C at an aircraft cruising altitude on a typical hot day. Cool ram air **102**, as will be shown below, may be used to create a temperature difference for a thermoelectric generator **106** to generate useful electric power.

Ram air **102** may be received through intakes on the aircraft. In one embodiment, the ram air may be introduced from a ram scoop. It may be recognized that ram air **102** may be taken from a variety of sources and is not limited to the ram air intake described above. Cool air may be substituted for or simultaneously refer to ram air **102**.

As will be shown, the bleed air **104** may be cooled using ram air **102** in order to filter and separate the air into nitrogen and oxygen by the nitrogen generation system **120**. Bleed air **104** often contains a portion of waste heat. Thermoelectric generation using the waste heat contained in bleed air **104** or nitrogen system does not in general increase the extraction of bleed air **104**.

Bleed air **104**, represented as dotted lines within **FIGURE 2**, is generally air received from an engine compressor or an independent motor driven compressor **108**. Using the ram air **102** and bleed air **104**, a temperature differential is produced which may allow the thermoelectric generator **106** to produce electrical power.

In most embodiments, the nitrogen generation system **120** is connected to the aircraft fuel tank **208**. Because nitrogen enriched air has an inerting function for fuel tanks, it may stabilize the fuel tank **108** from unwanted hazards.

Within the nitrogen generation system **120**, may be the ozone converter **212**, the thermoelectric generator with air-to-air heat exchanger **200**, and the filter / air separation stage **214**. As shown in **FIGURE 2**, the ozone converter **212** may receive incoming bleed air **104** before the thermoelectric generator with air-to-air heat exchanger **200**.

Bleed air **104** from the ozone converter **212** may be fed into the thermoelectric generator with the air-to-air heat exchanger **200**. The thermoelectric generator **106** may produce electrical energy using the temperature differential of the ram air **102** and the bleed air **104**. In addition, the air-to-air heat exchanger cools or lowers the temperature of the bleed air **104** using the ram air **102**. Cooling the air down allows it to be used by other systems within the aircraft. In one embodiment, the temperature of the cooled bleed air **104** is 85 °C. A portion of the ram air **102** used to cool the bleed air **104** may be expelled through the ram air exhaust 206.

Cooled bleed air **104** may then be sent to the filter / air separation stage **214**. The filter / air separation stage **214** may separate nitrogen and oxygen enriched fractions from the cooled bleed air **104**. There are numerous ways to separate the nitrogen and oxygen from each other known to those skilled in the relevant art. Nitrogen enriched air may then be sent to the fuel tank **208**.

While several components were described in **FIGURE 2**, one skilled in the relevant art will appreciate that fewer or additional parts may be placed within the nitrogen generation system **120**. The above-described nitrogen generation system **120** is for illustrative purposes and should not be construed as limiting to the scope of the present application.

In essence, the thermoelectric generator **106** integrated into the nitrogen generation system **110** may convert waste heat into electrical power. In one embodiment, the thermoelectric generator may provide electrical power about 10% of the waste heat carried in bleed air. This may be limited by the efficiency of the thermoelectric device. The thermoelectric device may also reduce the ram air **102** used to cool the bleed air **104**. When less ram air **102** is used, the aircraft air drag may also be reduced.

In previous nitrogen generation systems **120**, when bleed air **104** was cooled, heat content carried by the bleed air **104** was disposed through the ram air **102** cooling process. As shown in **FIGURE 3**, by coupling the thermoelectric generator **106** to the nitrogen generation system **120**, or to the other systems provided above, the thermoelectric generator **106** may produce electrical power **304** using the bleed air **104** taking advantage of the heat that would have otherwise been wasted. By passing the ram air **102** on one side of the thermoelectric generator **106** and bleed air **104** on the other, electrical power **304** is produced by the thermoelectric generator **106.**

The thermoelectric generator **106** may be a solid state power generation device. Typically, the generator **106** is compact, quiet, and very robust. Because of the lack of moving parts and its simplicity, the generator **106** may be low maintenance. Furthermore, the generator **106** may offer weight, volume, and cost savings for the aircraft power system.

Generally, the direction of the air flow of either the ram air **102** or the bleed air **104** does not affect the principle operation of the thermoelectric generator **106** as the thermoelectric generator **106** merely takes the differences in temperature between the two to generate electrical power **304**. In some embodiments, however, the air flow direction may affect overall energy conversion efficiency. As provided for in **FIGURE 3** and consistent with **FIGURE 2**, the ram air **102** is represented by longer lines and the bleed air **104** is depicted using dotted lines.

For illustrative purposes, and not limiting the presented application herein, **FIGURE 4** depicts one embodiment of a thermoelectric generator **106**. The generator **106** takes advantage of the thermal differential between opposing surfaces of a material. One surface **406** of the material may be exposed to a relatively hot temperature, while an opposing surface **408** may be exposed to a relatively cold temperature. The amount of electric voltage **304** typically depends on the temperature differential in the bleed air **104** and the ram air **102**. While most thermoelectric generators **106** are unable to regulate thermal differentials, the electric voltage **304** provided by the thermoelectric generator **106** within the nitrogen generation system **120** may provide a consistent voltage as the ram air **102** and the bleed air **104** are often received at consistent temperatures. Generally, electrical voltage **304** is generated when the temperature difference is above a threshold value.

As shown in **FIGURE 4**, the thermoelectric generator **202** may include an n-type element **402** and a p-type element **404**. Charge may flow through the n-type element **402** and into the p-type element **404** when the bleed air **104** is applied. Generally, electrons in the n-type element **402** may move opposite the direction of current and holes in the p-type element **404** may move in the direction of current, both removing heat from one side **406** of the thermoelectric generator **106** to the other **408**. The heat source may drive electrons in the n-type element **402** toward the cooler region, thus creating a current through the thermoelectric generator **106**. Holes in the p-type element **404** may then flow in the direction of the current. The current may then be used to power a load, thus converting the thermal energy into electrical energy **304**. When both ends **406** and **408** of the thermoelectric generator **106** are kept at a constant temperature difference, there is a constant power flow at a given load condition. Because heat is removed from the bleed air to generate electrical energy **204**, the amount of ram air **102** used to cool down the bleed air **104** may be reduced.

The thermoelectric generator **106** described above is one exemplary embodiment and should not be seen in a limiting scope. One skilled in the relevant art will appreciate that there are a many different types of thermoelectric generators **106** that may produce electrical power **304** using temperature differences. Furthermore, the bleed air **104** and the ram air **102** may be interchanged to flow on opposite ends to produce electrical energy **204**. For example, ram air **102** may be channeled across end **406**, while bleed air **104** may be channeled across end **408**.

Now referring to **FIGURE 5**, the thermoelectric generator with the air-to-air heat exchanger **200** is integrated into the nitrogen generation system **120** in accordance with one embodiment. As shown by the dotted line **526**, the thermoelectric generator with the air-to-air heat exchanger **200** may be placed into an existing nitrogen generation system **120** or any of the previous systems described above. System control **502** typically requires little to no changes for incorporating the thermoelectric generator with the air-to-air heat exchanger **200**.

The system control **502** may maintain and manage controllers through several control lines. In one embodiment, the controllers may be turned off or on. Alternatively, the controllers may be turned on or off to a certain level. For example, controllers may allow 90% of air flow to pass through. The system control **502**, in accordance with one embodiment, may be coupled to a ram air controller **506** through line **504**. Bleed air control valve **510** may be connected to the system control **502** through line **508** and bypass flow valve **514** may be connected to the system control **502** through line **512**.

In operation, a determined amount of ram air **102** and bleed air **104** may be fed into the nitrogen generation system **120**. By using control line **504**, the system control **502** may increase or reduce the amount of ram air **102** fed into the system **120** through controller **506**. As shown, the ram air **102** may be fed directly into the thermoelectric generator with the air-to-air heat exchanger **200** or may be filtered before going to the thermoelectric generator with the air-to-air heat exchanger **200**. The ram air **102** may then be expelled through the ram air exhaust **206**. As described above, the larger the amount of ram air intake, the more drag typically created within the aircraft.

In addition, control line **508** may be used by the system control **502** to increase or reduce the amount of bleed air **104** fed into the system **120** through control valve **510**. Typically, bleed air **104** may come from an engine or motor driven compressor **108**. The bleed air **104** may then be fed into the ozone converter **512** as depicted in **FIGURE 5**.

While the bleed air **104** still maintains its high temperature, the ozone converter **212** may reduce the levels of ozone within the bleed air **104**. The bleed air **104** may be passed through the thermoelectric generator with the air-to-air heat exchanger **200** or the thermoelectric generator with the air-to-air heat exchanger **200** may be bypassed altogether dependent on the bypass flow valve **514** and control line **512**. To determine whether the thermoelectric generator with the air-to-air heat exchanger **200** may be bypassed, the system control **502** may include a temperature monitoring line **516**. Typically, when the bleed air **104** is cool enough to be separated, the thermoelectric generator with the air-to-air heat exchanger **200** may be bypassed using bypass flow valve **514** and control line **512**. Alternatively, when the bleed air **104** is not cool enough, the bypass flow valve **514** may prevent bleed air **104** from flowing through causing the bleed air **104** to flow through the thermoelectric generator with the air-to-air heat exchanger **200**. In essence, the bypass flow valve **514** may monitor and control the temperature of the bleed air **104** provided to the filter / air separation stage **214**.

While the bypass flow valve **514** along with control line **512** may be used to monitored the temperature of the bleed air **104**, one skilled in the relevant art will appreciate that there are a number of ways to ensure that the filter / air separation stage **214** is provided with bleed air **104** having the correct temperature. In one embodiment, the system control **502** may reduce or increase the amount of bleed air **104** coming through bleed air control valve **510** using control line **508**. Alternatively, the amount of ram air **102** may be regulated by ram air controller **506** through line **504**.

After the bleed air **104** is cooled, the bleed air **104** may be fed into the filter / air separation stage **214** where the bleed air **104** may be separated into oxygen enriched air **522** and nitrogen enriched air **524**. The oxygen enriched air **522** may be provided as exhaust **106** while the nitrogen enriched air **524** may be placed in a fuel tank **208**, which as described earlier may remove volatile combinations of oxygen, fuel vapors, and ignition sources.

In typical embodiments, the system control **502** may indicate system status through a display **518**. The system control **502** may also be managed and manipulated through external controls **520**. System control **502** may take the form of an entirely hardware embodiment, an entirely software embodiment, or an embodiment containing both hardware and software elements. In one embodiment, the system control **502** is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc. The hardware may include a processing unit, a system memory, and a system bus that operatively couples various system components.

Previously, the thermoelectric generator with the air-to-air heat exchanger **200** was described as a single unit. **FIGURE 6** provides a block diagram illustrating a system architecture splitting the thermoelectric generator **106** and air-to-air heat exchanger **604** in accordance with another embodiment. The nitrogen generation system **120** may receive ram air **102** and bleed air **104** and expel ram air exhaust **206** and provide nitrogen enriched air to a fuel tank **208**.

As shown, the thermoelectric generator with the air-to-air heat exchanger **200** is expanded. The ram air **102**, indicated on the lower portion of the expanded section, may be first channeled through the thermoelectric generator **106** and then through a counter-flow air-to-air heat exchanger **604**. The bleed air **104**, provided on the top portion of the expanded portion, may be first provided to the thermoelectric generator **106**. Following, the bleed air **104** may be fed to the air-to-air heat exchanger **604**.

Typically, the relative air flow directions of ram air **102** and bleed air **104** may result in different temperature differentials in the course of flow, therefore it may have different electrical power **304** production. Using the ram air **102**, the bleed air **104** may be cooled to a temperature suitable for the filter / air separation stage **114** whereby the nitrogen generation system **110** separates the air into nitrogen and oxygen enriched fractions.

FIGURE 6A depicts the integration of the exemplary channeling for the ram air **102** and the bleed air **104** into the nitrogen generation system **120** in accordance with one embodiment. As shown, the controllers and control lines are similar to those described before. In the illustration, the bleed air **102** may be fed into the thermoelectric generator **106** first and then through the air-to-air heat exchanger **604**. The ram air **104** may be channeled first through the thermoelectric generator **106** and then through the counter-flow air-to-air heat exchanger **604**. Power may be produced by the thermoelectric generator **106** as a result of the temperature differential of the bleed air **104** and the ram air **102**. Because the thermoelectric generator **106** reduces some of the heat within the bleed air **104**, the amount of ram air **102** to cool down the bleed air **104** may be reduced.

FIGURES 6 and **6A** show illustrative channeling to feed the ram air **102** and bleed air **104** first to the thermoelectric generator **106** and then to the air-to-air heat exchanger **604**. One skilled in the relevant art will appreciate that there may be a number of different ways to channel the ram air **102** and the bleed air **104** within the nitrogen generation system **120**.

FIGURE 7 provides a block diagram illustrating a system architecture for an alternative channeling of the bleed air **104** and ram air **102** in accordance with one embodiment. Generally, the nitrogen generation system **120** may receive ram air **102** and bleed air **104** and expel ram air exhaust **206** and provide nitrogen enriched air to a fuel tank **208**. The thermoelectric generator with the air-to-air heat exchanger **200** is expanded as shown. The ram air **102**, indicated on the lower portion of the expanded section, may be first channeled through the backside of the thermoelectric generator **106** and then through the backside of the air-to-air heat exchanger **604**.

In addition, the bleed air **104**, provided on the top of the expanded portion, may first be provided to the thermoelectric generator **106**. Following, the bleed air **104** may be fed to the air-to-air heat exchanger **604**. The thermoelectric generator **106** may produce electrical energy **304** and the air-to-air exchanger **604** may cool the bleed air **104** for the filter / air separation stage **214** whereby the nitrogen generation system **120** separates the air into nitrogen and oxygen enriched fractions.

FIGURE 7A depicts the integration of an alternative channeling into the nitrogen generation system **120** in accordance with one embodiment. In the illustration, the bleed air **104** may be fed into the thermoelectric generator **106** first and then through the air-to-air heat exchanger **604**. The ram air **104** may be channeled first through the backside of the thermoelectric generator **106** and then through the backside of the air-to-air heat exchanger **604**. Electrical power **304** may be produced by the thermoelectric generator **106** as a result of the temperature differential of the bleed air **104** and the ram air **102**. Because the thermoelectric generator **106** reduces some of the heat within the bleed air **104**, the amount of ram air **102** to cool down the bleed air **104** may be reduced.

While two examples of channeling the ram air **102** and the bleed air **104** were shown, one skilled in the relevant art will appreciate that there are numerous configurations in channeling the air flow. Furthermore, the air-to-air heat exchanger **604** and the thermoelectric generator **106**, as previously shown, do not have to be separated, but instead may be incorporated into the same structure.

FIGURES 8A and **8B** depict one embodiment of a thermoelectric generator **106**. As depicted in **FIGURE 8A**, the thermoelectric generator **106** may include an inside tube **804** and an outside tube **806** with a thermoelectric element **802** between them. The thermoelectric generator **106** may receive ram air **102** through one end and bleed air **104** through the other. Using the temperature differential, the thermoelectric generator **202** may produce electrical energy **304**.

FIGURE 8B is a sectional side view of the thermoelectric generator **106** in accordance with one embodiment. As shown, the ram air **102** may be sent through the outside tube **806** while the bleed air **104** may be sent through the inside tube **804**. Between the outside tube **806** and the inside tube **804** may be thermoelectric elements **802** to generate electrical power **304**. While the ram air **102** may be provided through the outer tube **806** and the bleed air **104** within the inner tube **804**, they may be interchanged. Furthermore, the air flow may be switched depending on the channeling described above.

FIGURE 9A is a sectional side view of another thermoelectric generator **106**. As shown, the thermoelectric generator **106** may have one end **902** and a second end **904**. Separating each end may be a thermoelectric element **802**. As shown in **FIGURE 9B**, bleed air **104** may pass over end **902**, while ram air may pass over end **904** so that the thermoelectric element **802** may generated electrical power **304**. Each of the thermoelectric generators **106** can be provided within any system described above including, but not limited to, the systems shown in **FIGURE 1**.

While embodiments of the disclosure have been described in terms of various specific embodiments, those skilled in the art will recognize that the embodiments of the disclosure can be practiced with modifications within the spirit and scope of the claims.

CLAIMS

What is claimed is:

1. A device for producing electrical power comprising:

a bleed air system (100); and

a thermoelectric generator (106) coupled to said bleed air system (100) for generating said electrical power using temperature differentials between ram air and bleed air.

2. The device of claim 1, wherein said bleed air system (100) comprises:

an ozone converter (212) for reducing ozone levels within said bleed air; and

an air-to-air heat exchanger (200) for receiving said ram air and said bleed air from said ozone converter (212).

3. The device of claims 1 and 2, wherein said thermoelectric generator (106) is coupled to an air-to-air heat exchanger (200).

4. The device in any of claims 1-3, wherein said bleed air system (100) comprises a system control for monitoring and managing said ram air and said bleed air.

5. The device in any of claims 1-4, wherein an air-to-air heat exchanger (200) cools said bleed air using said ram air.

6. The device in any of claims 1-5, further comprising a nitrogen generation system (120) coupled to said thermoelectric generator (106).

7. A method for generating power on an aircraft bleed system comprising:

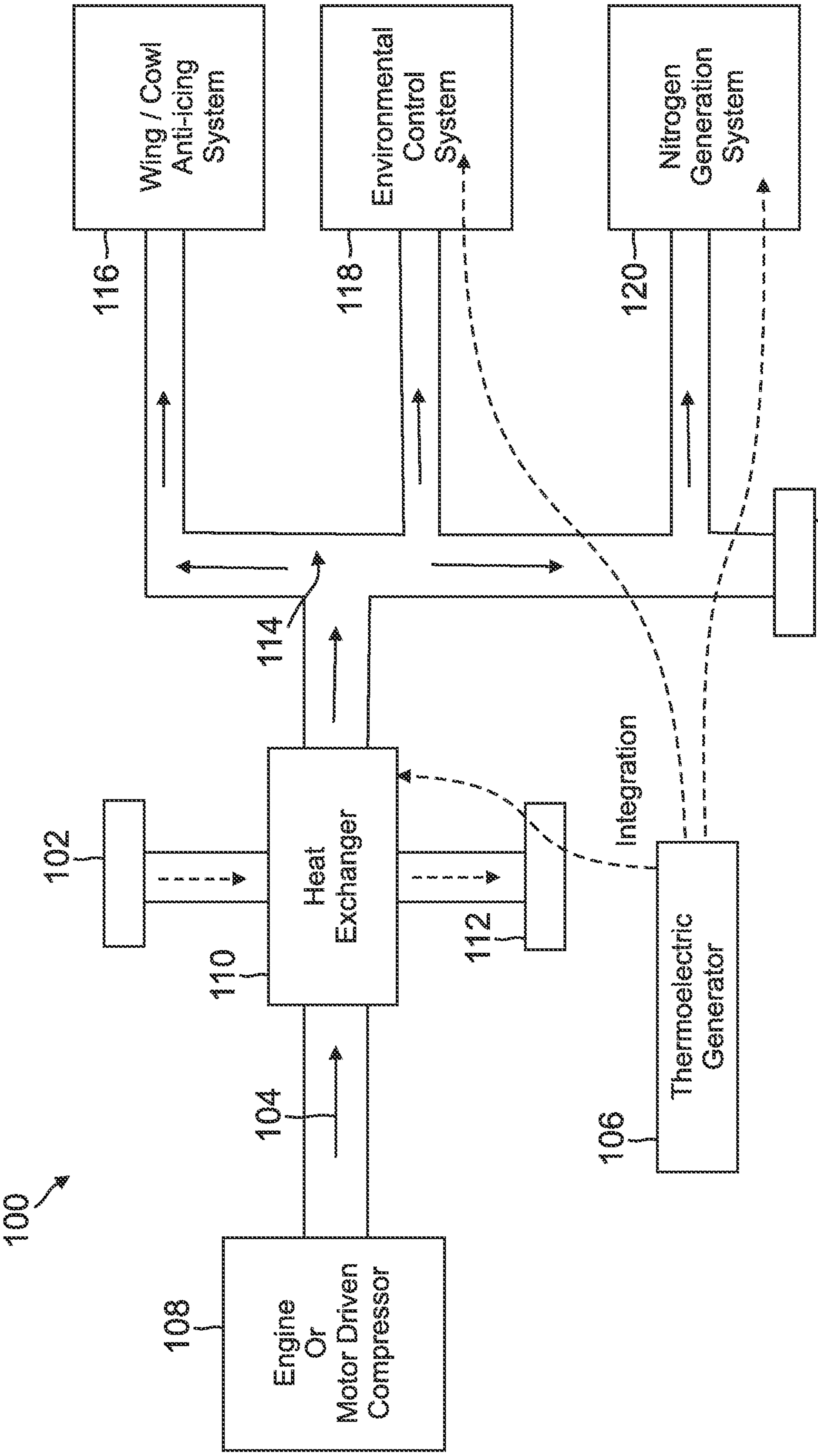
receiving ram air;

receiving bleed air; and

directing said ram air and said bleed air through a thermoelectric generator (106) coupled to said aircraft bleed system for generating electrical energy.

8. The method of claim 7, further comprising cooling said bleed air by said thermoelectric generator (106) reducing an amount of ram air used by said aircraft bleed system.

9. The method of claims 7 and 8, further comprising cooling said bleed air by said thermoelectric generator (106) reducing an amount of ram air used by said aircraft bleed system.



100
108
Engine Or Motor Driven Compressor
104
102
110
Heat Exchanger
112
106
Thermoelectric Generator
Integration
114
116
Wing / Cowl Anti-icing System
118
Environmental Control System
120
Nitrogen Generation System
122

FIG. 1

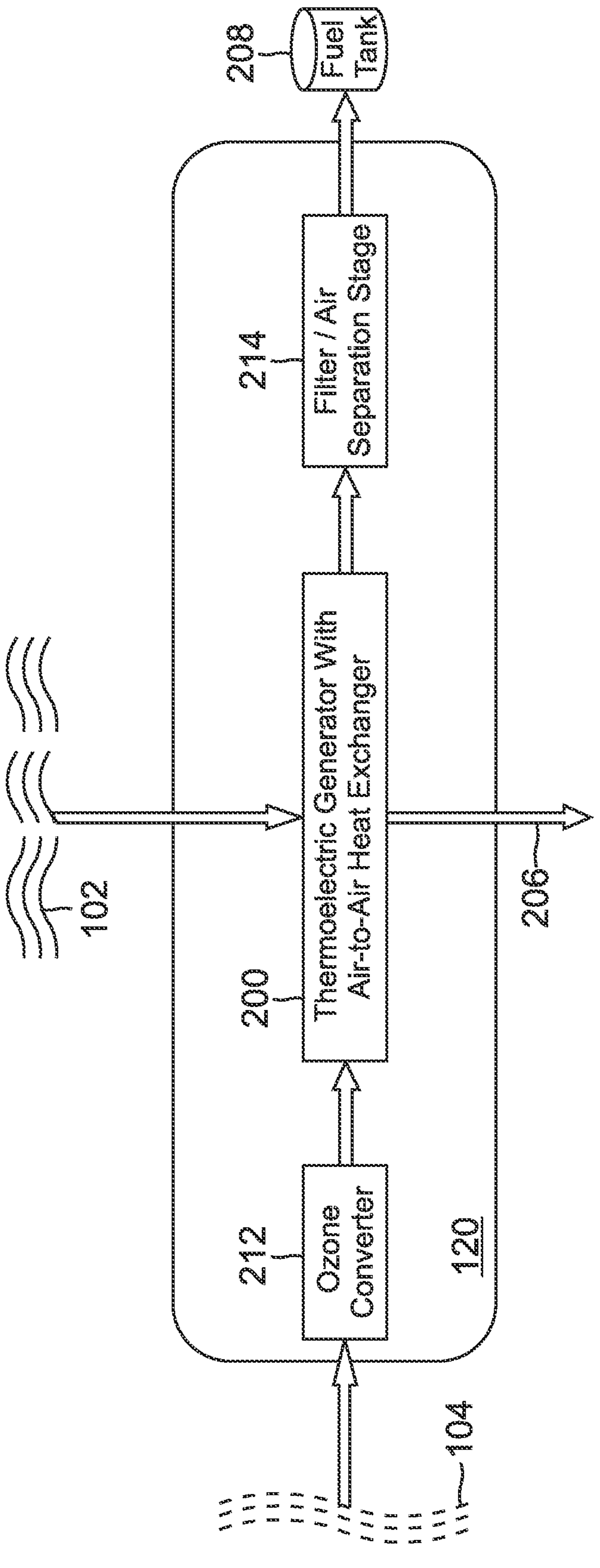

208
Fuel Tank
214
Filter / Air Separation Stage
200
Thermoelectric Generator With Air-to-Air Heat Exchanger
102
206
212
Ozone Converter
120
104

FIG. 2

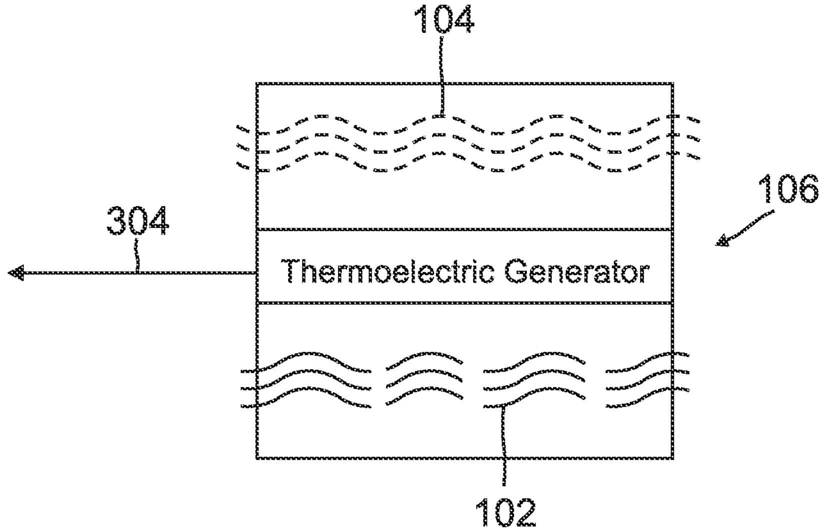

104
106
304
Thermoelectric Generator
102

FIG. 3

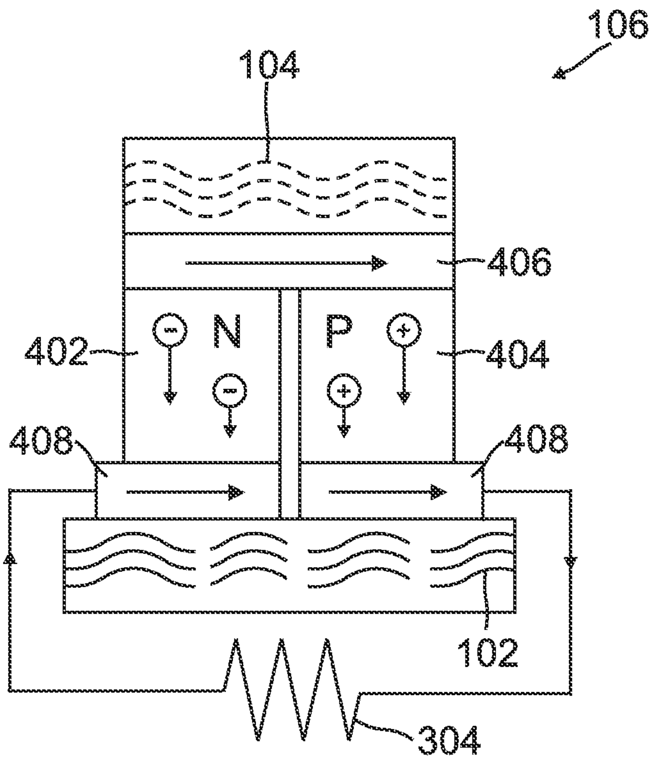

106
104
406
402
N
P
404
408
408
102
304

FIG. 4

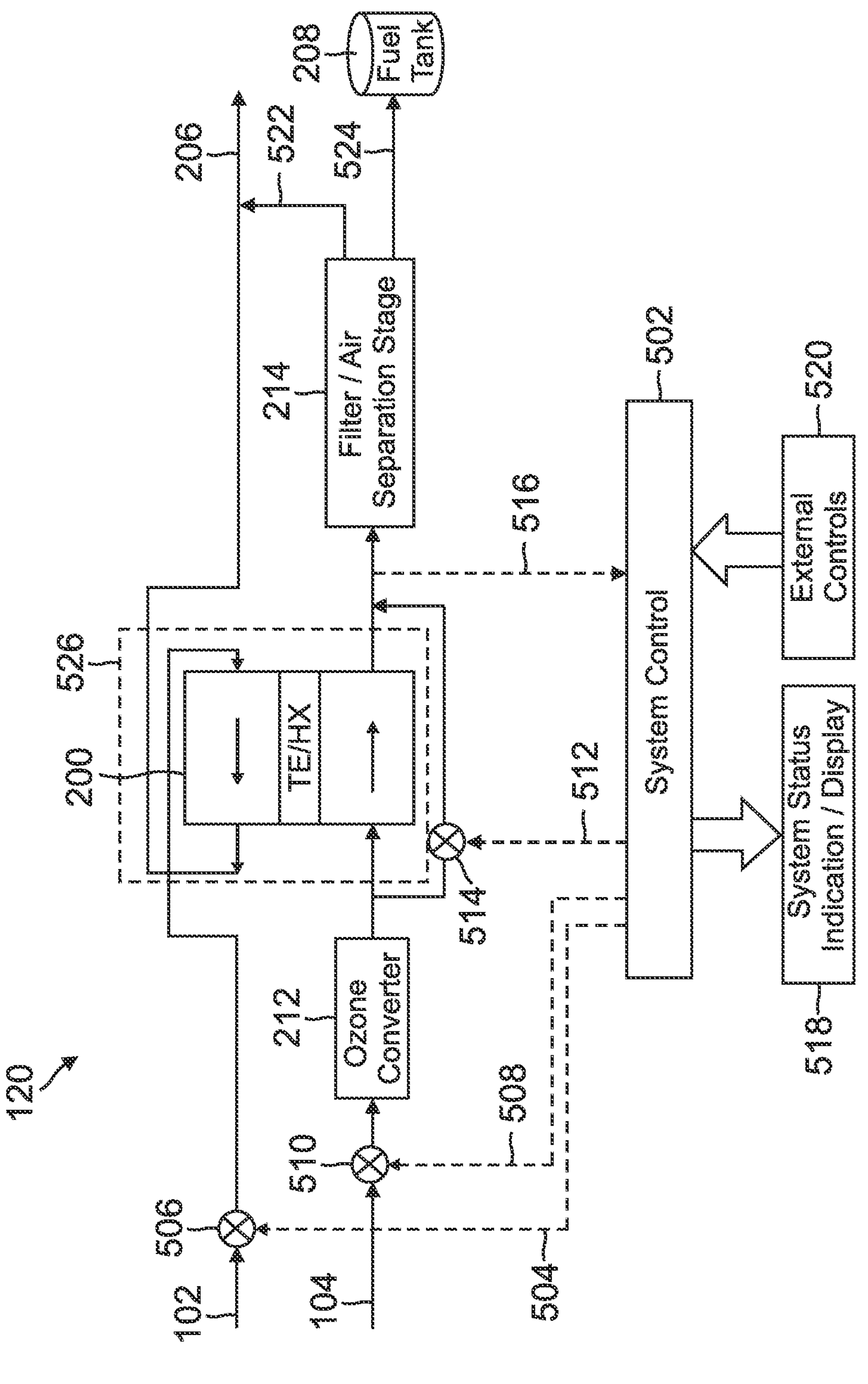

120
102
506
104
510
504
508
212
Ozone Converter
200
526
TE/HX
514
512
206
522
524
208
Fuel Tank
214
Filter / Air Separation Stage
516
502
System Control
520
External Controls
518
System Status Indication / Display

FIG. 5

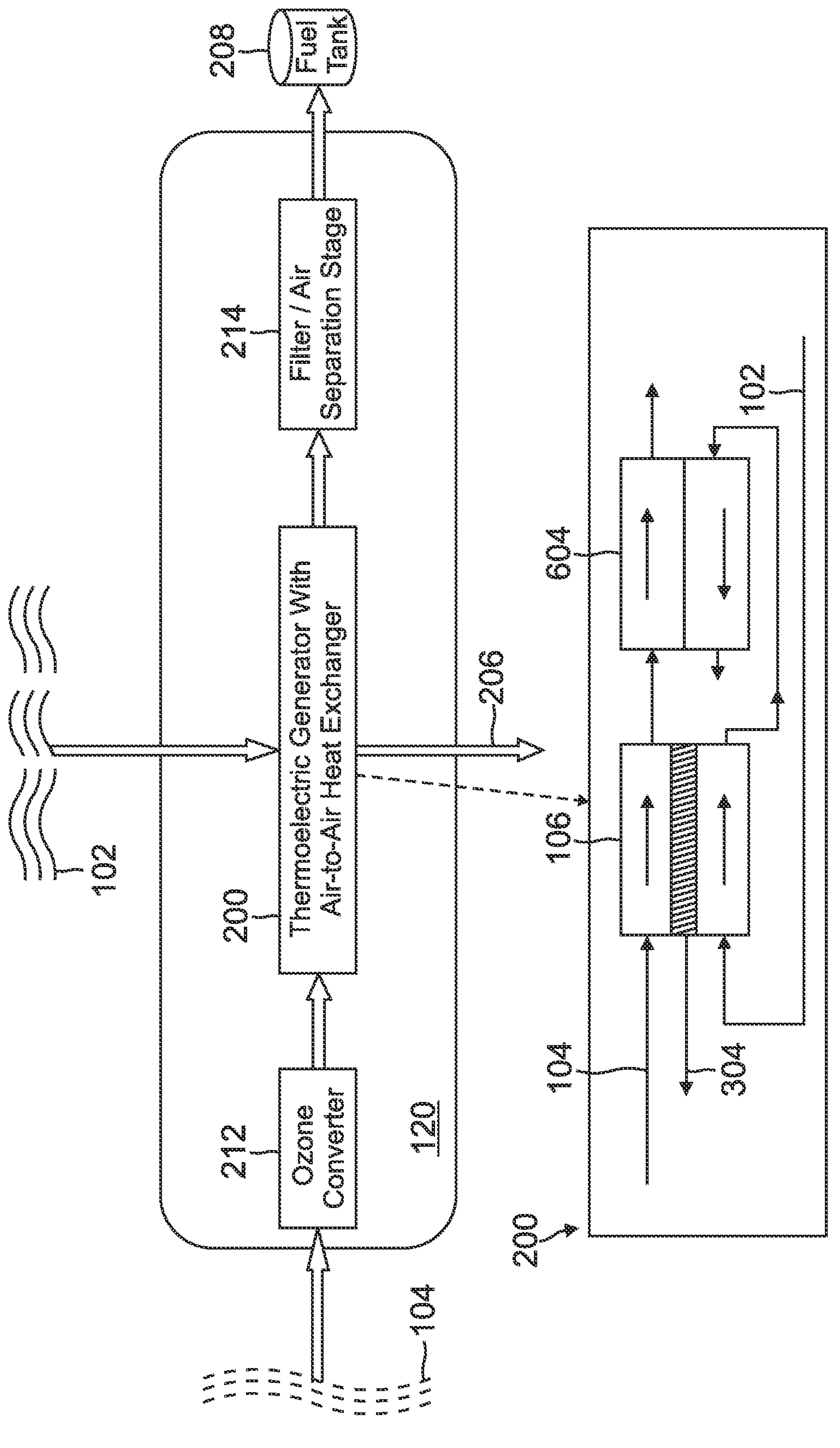

208
Fuel Tank
214
Filter / Air Separation Stage
200
Thermoelectric Generator With Air-to-Air Heat Exchanger
212
Ozone Converter
120
102
104
206
604
106
104
304
102
200

FIG. 6

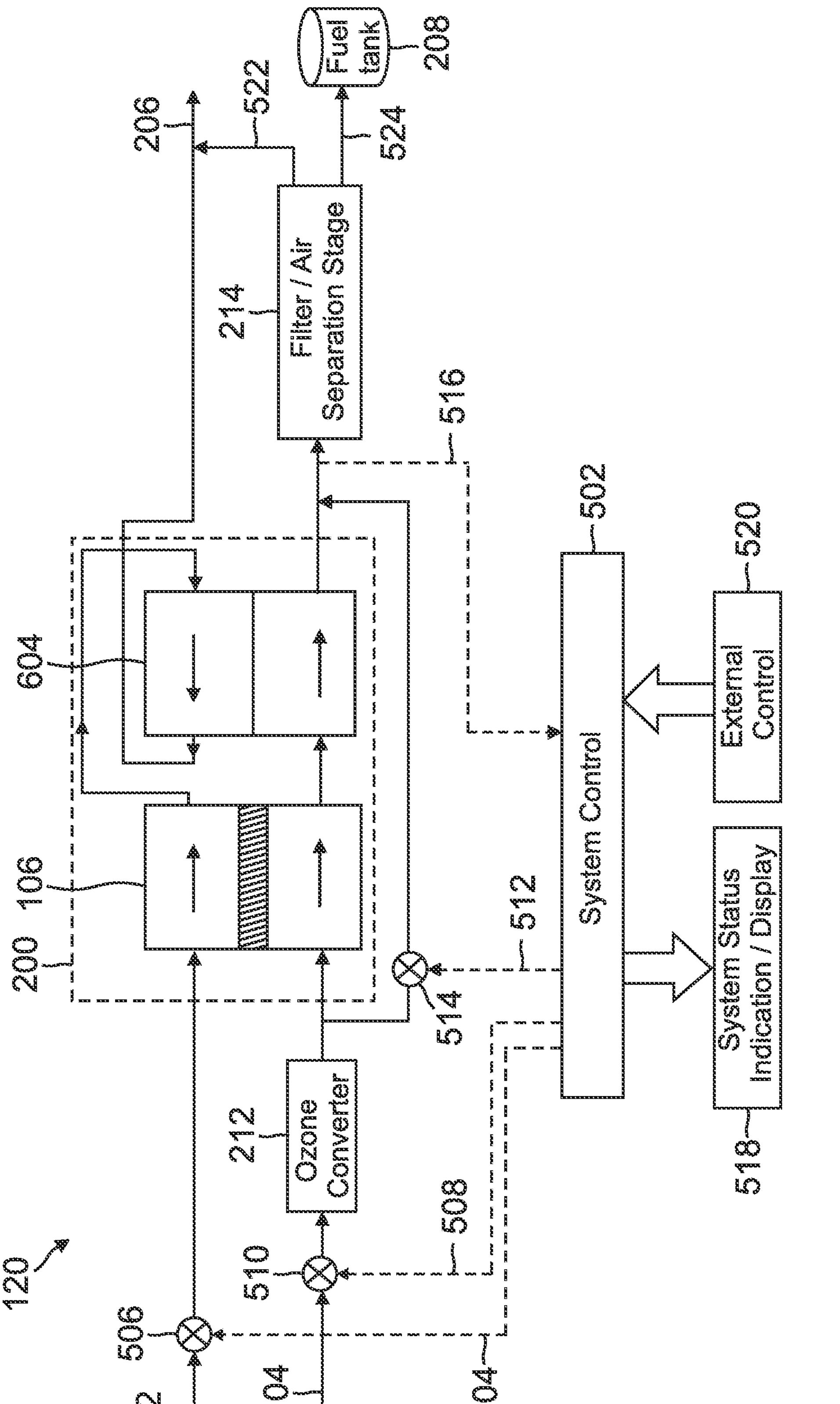
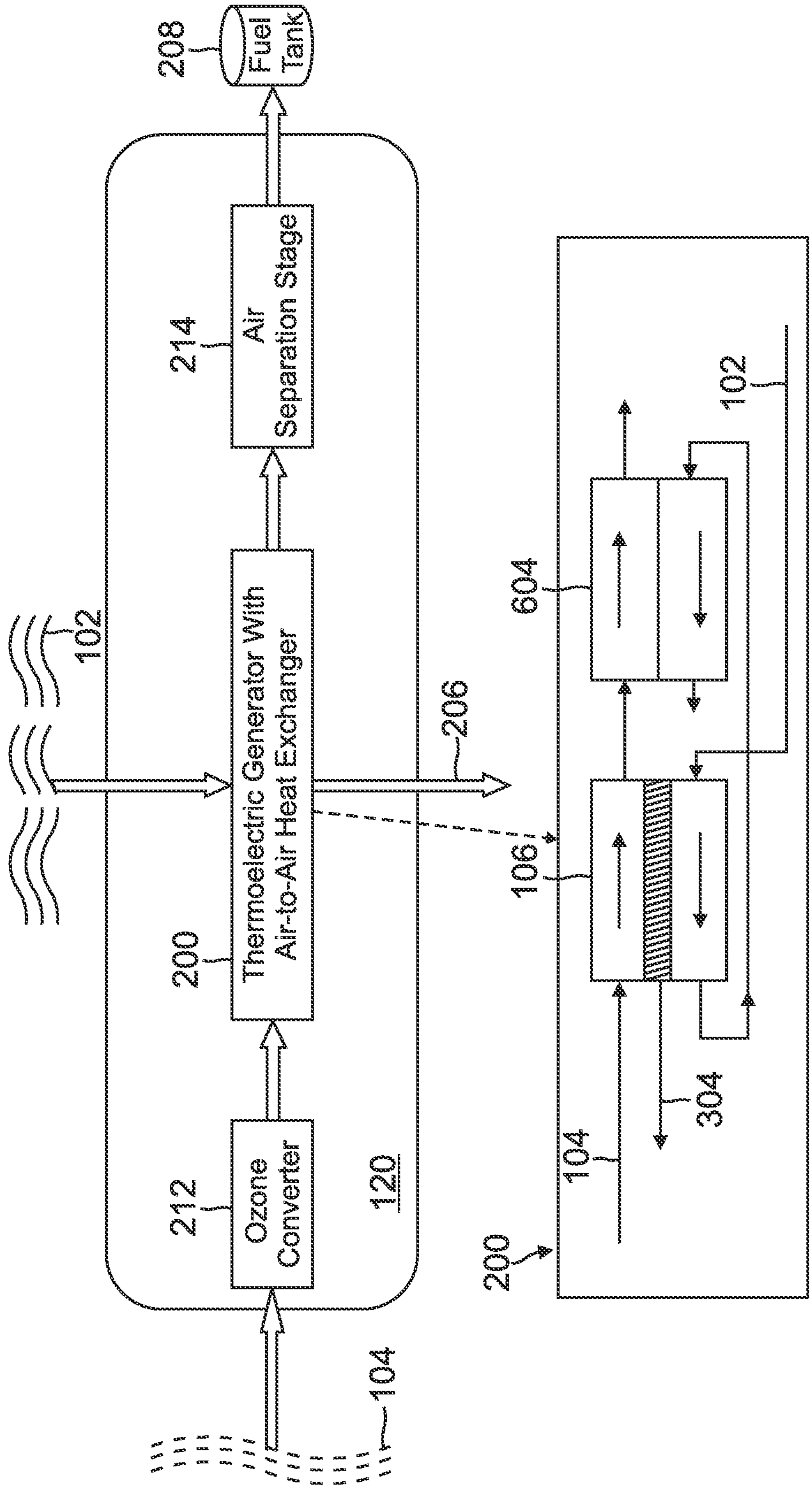

120
102
104
506
510
504
508
212
Ozone Converter
200
106
514
512
604
206
522
214
Filter / Air Separation Stage
516
524
Fuel tank
208
502
System Control
520
External Control
518
System Status Indication / Display

FIG. 6A



208
Fuel Tank
214
Air Separation Stage
102
Thermoelectric Generator With Air-to-Air Heat Exchanger
200
206
212
Ozone Converter
120
104
604
102
106
304
104
200

FIG. 7

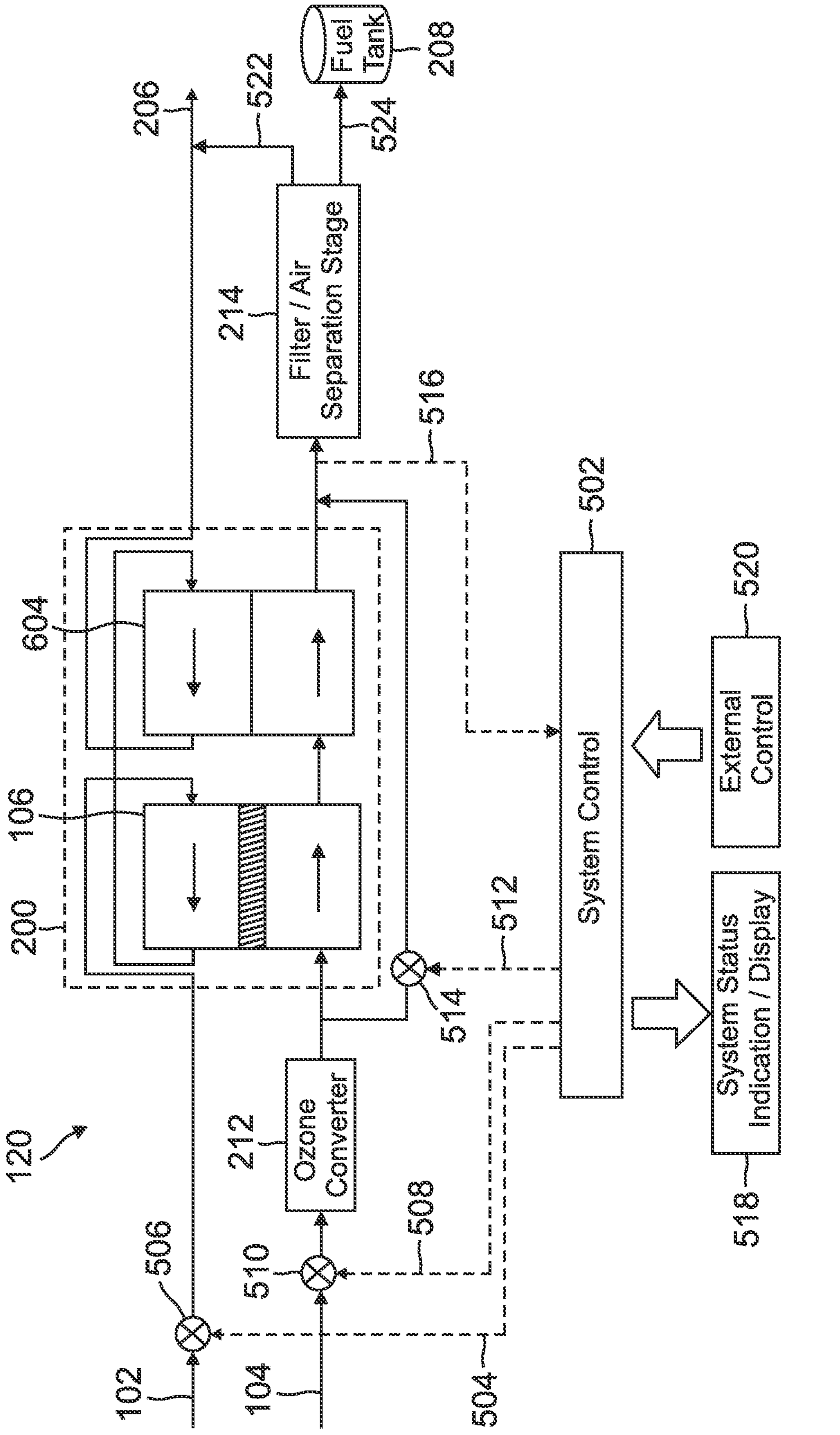

120
102
104
504
506
510
508
212
Ozone Converter
200
106
514
512
604
206
522
214
Filter / Air Separation Stage
524
Fuel Tank
208
516
502
System Control
520
External Control
518
System Status Indication / Display

FIG. 7A

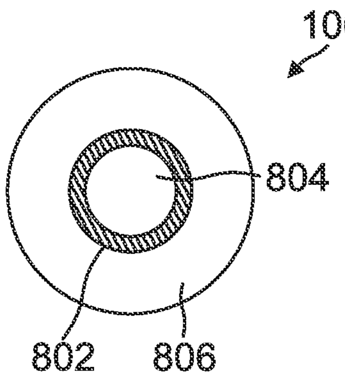


FIG. 8A

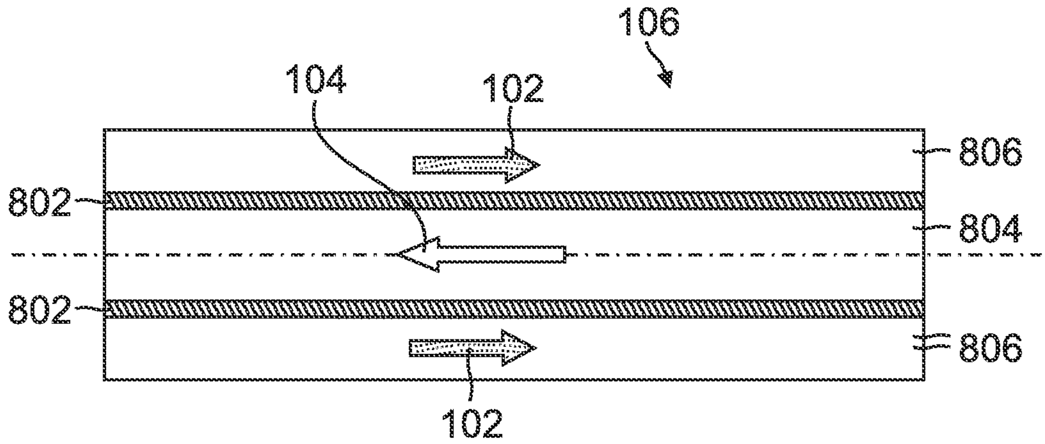


FIG. 8B

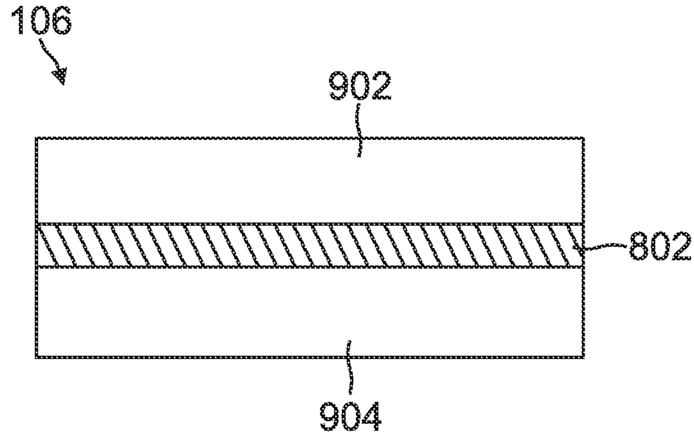


FIG. 9A

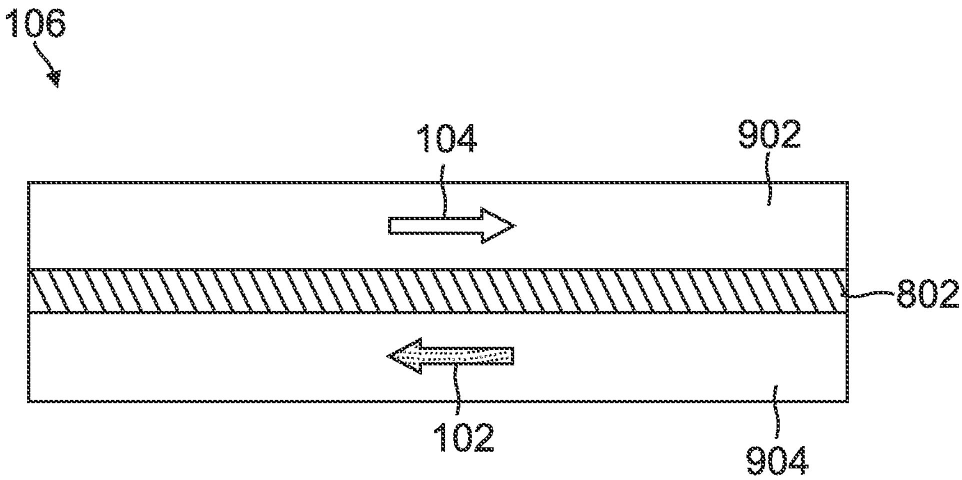


FIG. 9B