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REFRIGERATION AND VENTILATION DEVICE

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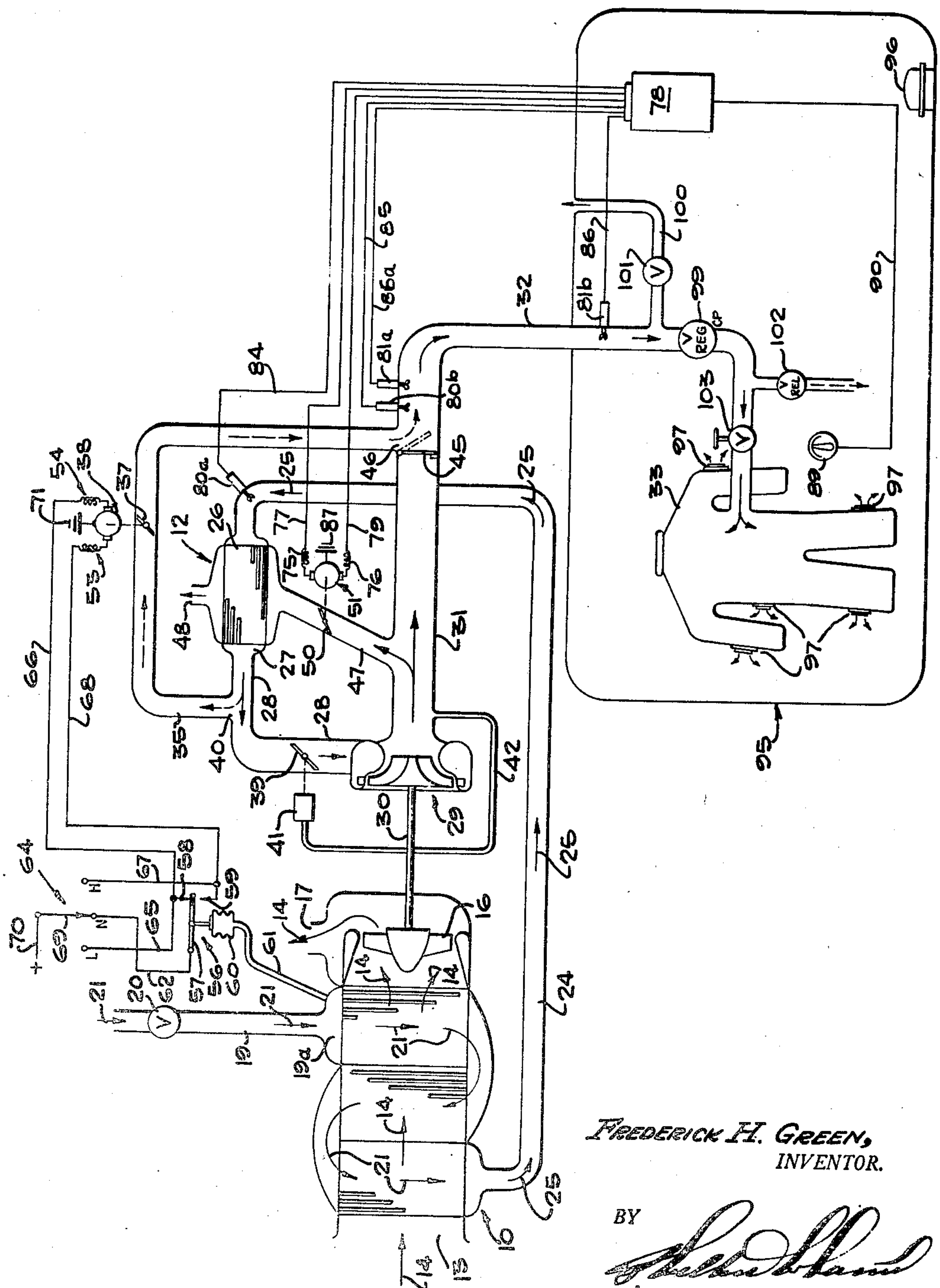

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REFRIGERATION AND VENTILATION DEVICE

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19 Claims. (Cl. 62—6)

This invention relates generally to a fluid conditioning apparatus and relates more particularly to refrigerating and ventilating apparatus.

While the invention has particular utility in apparatus for supplying air to certain types of flying suits for aircraft pilots and is hereinafter described and shown in connection therewith, it is to be understood that its utility is not limited thereto. Further, such suits may be broadly considered as enclosures.

The term aircraft, as used herein, may be considered to include various types of vehicles or devices which travel through the earth's atmosphere and, perhaps, beyond.

It is an object of the present invention to provide apparatus of the above character which will control the temperature and pressure of the air supplied to an enclosure and, hence, controls the temperature and pressure of the air in said enclosures.

Another object of the invention is to provide apparatus of this character having a separate control for the suit or enclosure.

Still another object of the invention is to provide apparatus of this character having modulating control means.

A further object of the invention is to provide apparatus of this character which will provide a relatively constant flow through said suit or enclosure.

A still further object of the invention is to provide apparatus of this character having a smooth temperature control.

Another object of the invention is to provide apparatus of this character which will prevent excessive suit pressure.

Still another object of the invention is to provide apparatus of this character adapted to minimize turbine back pressure.

A further object of the invention is to provide apparatus of this character which will operate without ram effect at the inlet of the heat exchanger.

Other objects and advantages of the invention will be brought out in the following part of the specification.

Referring to the drawing, which is for illustrative purposes only, there is schematically shown refrigerating and ventilating apparatus embodying the present invention.

Referring more particularly to the drawings, there is shown refrigerating and ventilating apparatus including a primary heat exchanger, indicated generally at **10**, and a regenerator, indicated generally at **12**.

Atmospheric air enters the heat exchanger **10** by way of an inlet **13** and follows the course indicated by the arrows **14**, said air being moved through the heat exchanger by means of a fan **16** at the end of said heat exchanger opposite the inlet **13** and such air is discharged to ambient atmosphere from the outlet **17**. Air to be cooled is derived from any suitable source such as an engine supercharger or the compressor of a jet engine. This air is under pressure and is delivered to the heat exchanger **10** by way of a conduit **19** delivering said air to the inlet **19a** of said heat exchanger, said conduit **19** having a shutoff valve **20** therein. The compressed air follows the path indicated by the arrows **21** through the heat exchanger and said air, when cooled, leaves said heat exchanger by way of conduit **24**, the flow of cooled air being indicated by the arrows **25**. Conduit **24** is connected with the inlet **26** of the regenerator **12** and may be further cooled therein. From the regenerator **12**, the air is discharged from outlet **27** into conduit **28** which leads to the inlet of an expansion turbine **29**. The turbine **29** is connected with the fan **16** by means of a shaft **30** whereby said fan is driven by said turbine. The turbine **29** discharges air into a conduit **31** which leads to a conduit **32** and the latter is connected with a suit **33**.

There is a passage **35** which branches from the passage or conduit **28** and which is connected to the conduit **31**. Passage **35** may be termed a bleed passage and is provided with a valve **37** for controlling the flow of air therethrough. The valve **37** is shown as a butterfly valve although any other type of suitable valve may be used. This valve is connected to and operated by a motor, indicated generally at **38**, to which said valve is connected. Valve **37**, during operation of the system, will be held in fully open or fully closed position. Movement of the valve between extremes is to be rapid. There also may be a valve **39** in the conduit **28** between the junction point **40** of said conduit with the conduit **35** and the turbine **29**. Valve **39** is also shown as a butterfly valve although it may be of any other suitable type and is connected to and operated by a pressure responsive device, indicated at **41**. Pressure responsive device **41** has a connection **42** with the conduit **31** so that outlet pressure of the turbine **29** is transferred to said device **41** which operates in response to variations in the differential of pressure between turbine back pressure and ambient atmosphere.

The conduit **31** is provided with a check valve **45** between the junction **46** with conduit **35** and the turbine **29**. Between said check valve **45** and turbine **29** is a branch passage or conduit **47** leading from said conduit **31** to the regenerator **12** for delivering cooled air to said regenerator, such air being discharged to atmosphere by way of the outlet **48**. Air flow through conduit **47** is controlled by a valve **50** which is shown as being a butterfly valve although any other suitable type of valve may be used. Valve **50** is connected to and controlled by a motor which is indicated generally at **51**.

Motor **38** is shown as being a reversible electrical motor having coils **53** and **54** for operating the motor in the valve closing and valve opening directions respectively and means for controlling the operation of said motor includes a pressure responsive switch, indicated generally at **56**.

Switch **56** includes a movable contact member **57** operably engageable with a pair of fixed contact members **58** and **59** which are spaced apart from each other and are adapted to be respectively contacted by the member **57**. Movable switch member **57** is connected to and adapted to be actuated by a pressure responsive device **60** which is shown as a bellows having its interior connected, by means of a conduit **61**, to the inlet **19a** of the heat exchanger **10** and having its exterior subjected to ambient atmospheric pressure so that said device is responsive to the differential of pressure between that derived from the compressed air source connected to the conduit **19** and ambient atmosphere. The movable contact member **57** is connected to a fixed contact N by means of a wire **62** which comprises one of the contacts of a manually controlled switch, indicated generally at **64**. Switch **64** also has a fixed contact L connected by a wire **65** to the fixed contact **58** and the latter is connected with the coil **54** of a motor **38** by means of a wire **66**. Switch **64** includes a third fixed contact H which is connected to the fixed contact **59** of switch **56** by means of a wire **67** and said contact **59** is connected with the coil **53** of motor **38** by means of a wire **68**. There is a movable contact member **69** in switch **64** which has a connection with a source of electrical energy by means of a wire **70**, said source of electrical energy also includes a ground, not shown, and motor **38** is grounded at **71**.

Motor **51** is also shown as a reversible electric motor and is provided with a pair of coils **75** and **76** respectively for operating the motor in the valve closing direction and valve opening direction. Coil **75** is connected by a wire **77** with a temperature regulator **78** and coil **76** is connected with said regulator **78** by means of a wire **79**. There are anticipators **80a** and **80b** in the conduits **24** and **31** respectively and a duct pick-up **81a** in conduit **31** or alternately **81b** in duct **32** and said anticipators and pick-up are connected by wires 84, 85, 86a and 86 to said temperature regulator 78 which controls the operation of motor 51 in accordance with the rate of change of temperature at anticipators 80a and/or 80b and the temperature at pickup 81a or 81b. Motor 51 is also grounded at 87. A temperature selector 89 is connected by means of a wire 90 to the temperature regulator 78, said selector 89 being located in any position so as to be readily accessible to adjustment by the pilot. The construction and operation of the regulator 78 is fully disclosed in the Brown and Shank application for Electronic Temperature Regulator, filed March 26, 1949, Serial No. 83,676, so that it is believed to be unnecessary to go into detail relative to this part of the apparatus in this application.

A pressurized aircraft cabin is indicated generally at 95 and is provided with a suitable source of air under pressure by any well-known means, not shown. Cabin 95 is provided with a pressure regulator 96 of any suitable well-known character so that there will be a flow of air through said cabin. The pilot with his suit 33 is in the cabin 95 and said suit has outlet valve means shown as comprising a plurality of outlet valves 97. Conduit 32, which leads to suit 33, is provided with a pressure control valve 99 adapted to regulate the pressure to the suit and provide thereto a constant pressure. Upstream of the valve 99, the conduit 32 has a bleed connection 100 to a lower pressure region such as ambient atmosphere or the cabin, which connection is controlled by a manually operable valve 101. Between the regulating valve 99 and the suit 33 is a pressure relief valve 102 discharging similarly into a region of lower pressure. Between the pressure relief valve 102 and the suit is a manually operable shutoff valve 103 which may be controlled by the pilot. The unit shown and described herein supplied air only for the pilot's suit and conditioned air for the cabin or pilot compartment is, in an installation of this type, supplied by an entirely different unit, not shown. Compressed air for the two systems may be supplied from the same source but the pressure required at the outlet of the regeneration system supplying air to the pilot's suit, that is, at the inlet to the suit, is higher than cabin pressure. The temperature of the air selected for delivery to the suit is also usually different from the temperature of the air selected for delivery to the cabin and, therefore, a separate temperature control system is used for the system supplying air to the suit. As shown herein, all the compressed air for the system passes through both the primary heat exchanger 10 and the regenerator 12. The path of flow of the air, after it leaves the regenerator, is dependent upon whether the bypass valve 37 is in the open or the closed position. As has already been stated, the pressure responsive valve mechanism 56, which controls the positioning of the valve 37, responds to variations in the differential of pressure between that of the air supplied to the system and ambient atmospheric pressure. It is to be understood, of course, that other pressure differentials may be employed. For example, there may be used the pressure differential between that of the air supplied to the system and cabin pressure or the absolute pressure of the air supplied to the system may be used in controlling the position of the movable switch member 57.

The pressure of the air supplied to the system depends upon the altitude of the aircraft and engine speed. At low altitudes where the differential between the air supplied to the system and ambient pressure is greater than the differential for which the pressure responsive switch 56 is set, the bypass valve 37 will be closed and all of the air supplied to the system will pass through the turbine 29. Part of the air leaving the turbine will flow through the conduits 31, check valve 45 and conduit 32 into the suit. Another portion of the air which passes through the turbine 29 flows through the branch passage 47, past valve 50, through the regenerator 12 and out to atmosphere. It is to be noted that air which passes from the conduit 19 through the primary heat exchanger 10, conduit 24, regenerator 12 and turbine 29 undergoes cooling by said heat exchanger 10, regenerator 12 and turbine 29.

Control of the temperature of the air delivered to the suit is effected by positioning of the valve 50 which, in turn, is controlled by the actuating motor 51, the latter being under the control of the temperature regulator 78 which, in turn, is set for the desired temperature by the manually actuated selector 89. The regulator 78 is subject to a duct pickup control 81a or 81b and also is subject to the rate of change anticipated control from the anticipators 80a and 80b. When the pilot selects the desired temperature on the temperature selector switch 89, which has an approximate rate of 50° F. to 120° F., the system will then function to control the temperature of the air in accordance with such selection at the pickup 81a or 81b.

Further modulation is effected by means of the flow control valve 39 which is controlled by the pressure responsive device 41, the latter being sensitive to back pressure in the turbine outlet duct 31 and when that back pressure becomes greater than a predetermined amount above ambient, for example 5 p. s. i., the flow control valve 39 moves toward closed position for restricting flow to the turbine. This not only minimizes turbine back pressure but also provides a smooth temperature control since it controls the total flow and, therefore, the energy delivered to the turbine and, hence, the fan air flow through the primary heat exchanger 10. The inlet 13 of the primary heat exchanger 10 is preferably not subjected to ram effect.

When the airplane is flying at high altitude or low speed at low altitudes where the differential between the pressure of air delivered to the system and ambient pressure is less than the differential for which the switch 56 is set, opening movement of the valve 37 will be effected. When the latter valve opens, the check valve 45 will automatically close and the air in the system will follow the divided path provided at the discharge end of the regenerator. Some of the air will pass through the conduit 35, passage 32, through the regulating valve 99 and, thence, to the suit 33. The balance of the air from the regenerator will pass through the turbine 29, into conduit 31 and thence to branch conduit 47, through the cooling passages of the regenerator 12 and thence to atmosphere. The suit during this phase of the operation receives air from the upstream side of the turbine 29 instead of the downstream side thereof. The temperature control system will still operate as described above but its action on the air will be indirect, that is, through the regenerative heat exchanger, there being no air flow directly from the turbine to the suit.

When flying at high altitude, the pressure required in the suit may be almost as great as the pressure of the air introduced into the system. In that case, the bypass valve 37 will be open so that the air which passes through the regenerator 12 will flow through the conduit 35 and thence to conduit 32 and the suit. Also opening of the valve 37 will increase the pressure drop across the turbine due to the fact that the air passing through the turbine will now exhaust to ambient atmosphere. The increase in pressure drop across the turbine will provide a greater drop in temperature of the air passing through the turbine.

Adjustment of the valve 50 in the conduit 47 will simultaneously effect changes at the primary heat exchanger 10, turbine 29, and regenerator 12. For example, if the valve 50 is moved towards the closed position, the reduced amount of cooling air flowing through the regenerator 12 will result in an increase in the temperature of the air at discharge 27 of regenerator 12. Moreover, the closing of the valve 50 will increase the back pressure at the turbine outlet, thereby reducing the pressure drop across the turbine and providing less temperature drop through the turbine. This will also effect reduction in the speed of the turbine which will, in turn, reduce the speed of the cooling fan 16 in the primary heat exchanger 10 thereby drawing less air through said primary heat exchanger which will usually result in increasing the temperature in conduit 25. It is to be noted that this same temperature control works whether the valve 37 is open or closed.

To safeguard the pilot from surges of excessively hot air, the temperature control valve 50 utilizes an extremely slow actuator so as to minimize hunting of the control elements in the regenerative circuit. Another method of controlling the valve 50 is to provide an actuator which will effect quick opening of the valve and slow closing thereof.

An additional safeguard is the provision of limit switches for the valve 50 mechanism which have been adjusted so that the valve cannot close completely. Further, the temperature regulator 78 may be adjusted to give very short pulses with dead bands as desired and separate modulation band settings on each side such that the current to the valve may always pulse and never become steady.

The pressure control valve 99 is shown as being installed within the pressurized cabin and is calibrated to maintain the suit inlet pressure at a predetermined pressure above cabin pressure, for example 5 p. s. i. at all times when sufficient pressure is supplied to the valve. This constant differential gives a relatively constant flow through the suit. It is necessary, of course, to maintain the pressure in the suit somewhat above the pressure of the region into which the suit exhausts.

It is to be understood that the suit, when worn by the pilot, is to be made air tight at the ankles, wrist and neck so that the only means of escape for the air in the suit is through the various outlet valves 97 of said suit.

The pressure relief valve 102 may be set for a predetermined pressure above the setting of the pressure control valve 99 and when this pressure is exceeded, air from conduit 32 is exhausted into the cabin to reduce pressure to the set value.

When starting, the valve 37 is open. It will not close until the differential between the pressure of the air supplied to the system and ambient pressure is greater than the differential for which the pressure switch 56 is set. Should the pilot wish to close valve 37 when the automatic control mechanism therefor has the valve in the open position, the pilot can operate the manual controls to keep said valve closed. Switch 64 provides such manual control which will override the control of the pressure responsive switch 56. Alternatively, there may be a switch on the landing gear which, when the landing gear is in use, will maintain the valve 37 in the closed position.

Other manual controls for the apparatus include the valve 103 which is manually operable for controlling flow into the suit in accordance with the desires of the pilot or other occupant of said suit. There is, of course, the manually controlled temperature selector device 89 which the pilot may also use in the control of the temperature of the air supplied to the suit. The valve 101 may be opened to permit air to bleed from the duct 32 into an unpressurized area and this valve may be used for test purposes or balancing of various components of the apparatus.

I claim:

1. Apparatus for conditioning compressed air from a source of compressed air to an enclosure, comprising: first cooler means having first and second passage means in heat transfer relation to each other; second cooler means having first and second passage means in heat transfer relation to each other; means for directing a flow of compressed air from said source through the first passage means of the first cooler means and thence to the first passage of the second cooler means; means for directing a flow of coolant through the second passage means of the first cooler means for cooling the compressed air flowing through the first passage means of the first cooler means; fan means for effecting a flow of coolant through said second passage means of the first cooler means; an expansion turbine having an inlet and an outlet; means operably connecting said turbine with said fan; passage means connecting the second cooler means with the inlet of said turbine whereby compressed air passing through the second cooler means is conducted to said turbine; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of the second cooler; a branch passage branching from the passage from the second cooler to the turbine and connected with the turbine outlet passage; a check valve in the turbine outlet passage upstream of the junction thereof with the second mentioned branch passage; valve means controlling the flow of air through said second mentioned branch passage; means for controlling said valve comprising pressure responsive switch means responsive to variations in the differential of pressure between that of the air supplied to the system at the first mentioned cooler means and ambient atmosphere; a valve controlling the turbine outlet branch passage; and temperature responsive means connected with the last mentioned valve means for controlling same.

2. Apparatus for conditioning compressed air from a source of compressed air to an enclosure, comprising: first cooler means having first and second passage means

in heat transfer relation to each other; second cooler means having first and second passage means in heat transfer relation to each other; means for directing a flow of compressed air from said source through the first passage means of the first cooler means and thence to the first passage of the second cooler means; means for directing a flow of coolant through the second passage means of the first cooler means for cooling the compressed air flowing through the first passage means of the first cooler means; fan means for effecting a flow of coolant through said second passage means of the first cooler means; an expansion turbine having an inlet and an outlet; means operably connecting said turbine with said fan; passage means connecting the second cooler means with the inlet of said turbine whereby compressed air passing through the second cooler means is conducted to said turbine; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of the second cooler; a branch passage branching from the passage from the second cooler to the turbine and connected with the turbine outlet passage; a check valve in the turbine outlet passage upstream of the junction thereof with the second mentioned branch passage; valve means controlling the flow of air through said second mentioned branch passage; means for controlling said valve comprising pressure responsive switch means responsive to variations in the differential of pressure between that of the air supplied to the system at the first mentioned cooler means and ambient atmosphere; a valve controlling the turbine outlet branch passage; temperature responsive means connected with the last mentioned valve means for controlling same; and pressure regulating means in the connection to the enclosure for providing a substantially constant pressure to said enclosure.

3. Apparatus for conditioning compressed air from a source of compressed air to an enclosure, comprising: first cooler means having first and second passage means in heat transfer relation to each other; second cooler means having first and second passage means in heat transfer relation to each other; means for directing a flow of compressed air from said source through the first passage means of the first cooler means and to the first passage of the second cooler means; means for directing a flow of coolant through the second passage means of the first cooler means for cooling the compressed air flowing through the first passage means of the first cooler means; fan means for effecting a flow of coolant through said second passage means of the first cooler means; an expansion turbine having an inlet and an outlet; means operably connecting said turbine with said fan; passage means connecting the second cooler means with the inlet of said turbine whereby compressed air passing through the second cooler means is conducted to said turbine; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of the second cooler; a branch passage branching from the passage from the second cooler to the turbine and connected with the turbine outlet passage; a check valve in the turbine outlet passage upstream of the junction thereof with the second mentioned branch passage; valve means controlling the flow of air through said second mentioned branch passage; means for controlling said valve comprising pressure responsive switch means responsive to variations in the differential of pressure between that of the air supplied to the apparatus at the first mentioned cooler means and ambient atmosphere; a manual override switch controlling said valve control means; a valve controlling the turbine outlet branch passage; temperature responsive means connected with the last mentioned valve means for controlling same; pressure regulating means in the connection to the enclosure for providing a substantially constant pressure to said enclosure; and manually controlled valve means in said passage between the pressure relief means and said enclosure.

4. Apparatus for conditioning compressed air from a source of compressed air to an enclosure having valve controlled outlet means, comprising: first cooler means having first and second passage means in heat transfer relation to each other; second cooler means having first and second passage means in heat transfer relation to each other; means for directing a flow of compressed air from said source through the first passage means of the

first cooler means and to the first passage of the second cooler means; means for directing a flow of coolant through the second passage means of the first cooler means for cooling the compressed air flowing through the first passage means of the first cooler means; fan means for effecting a flow of coolant through said second passage means of the first cooler means; an expansion turbine having an inlet and an outlet; means operably connecting said turbine with said fan; passage means connecting the second cooler means with the inlet of said turbine whereby compressed air passing through the second cooler means is conducted to said turbine; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of the second cooler; a branch passage branching from the passage from the second cooler to the turbine and connected with the turbine outlet passage; a check valve in the turbine outlet passage upstream of the junction thereof with the second mentioned branch passage; valve means controlling the flow of air through said second mentioned branch passage; means for controlling said valve comprising pressure responsive switch means responsive to variations in the differential of pressure between that of the air supplied to the system at the first mentioned cooler means and ambient atmosphere; a manual override switch controlling said valve control means; a valve controlling the turbine outlet branch passage; temperature responsive means connected with the last mentioned valve means for controlling same; pressure responsive valve means controlling the passage from the second cooler means to the turbine inlet and located between the junction of the branch passage thereof and the turbine inlet, said pressure responsive valve means being responsive to variations in the differential of pressure between turbine back pressure and ambient atmosphere; pressure regulating means in the connection to the enclosure for providing a substantially constant pressure to said enclosure; pressure relief means in the passage to the enclosure, said pressure relief means being located between the pressure control means and said enclosure; manually controlled valve means in said passage between the pressure relief means and said enclosure; and manually controlled bleed means adapted to connect the passage to the enclosure with atmosphere, said bleed means being connected with said passage upstream of said pressure regulating means.

5. Apparatus for conditioning compressed air from a source of compressed air to an enclosure, comprising cooler means having first and second passage means in heat transfer relation to each other; an expansion turbine having an inlet and an outlet; means for directing flow of compressed air from said source through the first passage means and to said turbine inlet; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of said cooler means; a branch passage branching from the passage from said cooler to the turbine inlet, said branch passage being connected with said turbine outlet passage downstream of the point of connection with said outlet branch; a check valve in the turbine outlet passage between the junctions of said branch passages with said outlet passages; valve means controlling the flow of air through the second mentioned branch passage; means for controlling said valve comprising pressure responsive switch means responsive to variations in the differential of pressure between that of the air supplied to the apparatus and ambient atmosphere; a valve controlling the turbine outlet branch passage; and temperature responsive means connected with the last mentioned valve means for controlling same.

6. Apparatus for conditioning compressed air from a source of compressed air to an enclosure, comprising: cooler means having first and second passage means in heat transfer relation to each other; an expansion turbine having an inlet and an outlet; means for directing flow of compressed air from said source through the first passage means and to said turbine inlet; turbine outlet passage means connecting the outlet of said turbine with said enclosure; a turbine outlet branch passage connecting said turbine outlet passage means with the second passage means of said cooler means; a branch passage branching from the passage from said cooler to the turbine inlet, said branch passage being connected with said turbine outlet passage downstream of the point of connection with said outlet branch; a check valve in the turbine outlet passage between the junctions of said branch passages with said outlet passages; a valve controlling the turbine outlet branch passage; and temperature responsive means operably connected with said valve and controlling same.

7. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; and bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage.

8. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and pressure responsive means controlling the flow of fluid through said bypass passage.

9. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; means responsive to one of the characteristics of the fluid in the apparatus controlling the flow of fluid through said branch passage means; and bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage.

10. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; means responsive to a variable characteristic of the fluid in the apparatus controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and means controlling the flow of fluid through said bypass passage.

11. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compart-

ment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and pressure responsive means controlling the flow of fluid through said bypass passage means.

12. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; pressure responsive means controlling the flow of fluid through said bypass passage means; and a pressurized enclosure, said compartment being located within said pressurized enclosure.

13. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; pressure responsive means controlling the flow of fluid through said bypass passage means; a pressurized enclosure, said compartment being located within said pressurized enclosure; and valve means for said compartment, said valve means opening when the pressure in said compartment is above a predetermined value.

14. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and a check valve in the outlet passage means upstream of the junction of the bypass passage means with the outlet passage means.

15. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and check valve means in the outlet passage means between the junctions of said branch passage and bypass passage with the outlet passage.

16. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; temperature responsive means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and pressure responsive means for controlling the flow of fluid to the second cooler means, said pressure responsive means being subjected to back pressure at the outlet of said second cooler means.

17. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and a check valve in the outlet passage means upstream of the junction of the bypass passage means with the outlet passage means.

18. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; means responsive to one of the characteristics of the fluid in the apparatus controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage means having an outlet connection with the outlet passage means downstream of said branch passage; and a check valve in the outlet passage means upstream of the junction of the bypass passage means with the outlet passage means.

19. In apparatus for conditioning a gaseous fluid which is conducted from a source of said fluid to a compartment: first cooler means having first and second passage means in heat transfer relation; second cooler means having an

inlet and an outlet; means directing a flow of gaseous fluid from said source through said first passage means to said inlet; outlet passage means connecting said outlet with said compartment; branch passage means directing a flow of gaseous fluid from said outlet through said second passage means to cool the gaseous fluid which flows through the first passage means; means controlling the flow of fluid through said branch passage means; bypass passage means adapted to receive fluid from the first passage means and connected thereto between the first cooler means and the second cooler means, said bypass passage

means having an outlet connection with the outlet passage means downstream of said branch passage; and a check valve in the outlet passage means urged in the closing direction by pressure in said bypass passage means.

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Number	Name	Date
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