Feb. 17, 1953 G. A. BURGESS 2,628,482

AIR CONDITIONING MEANS FOR ENCLOSURES

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Fig. 1.

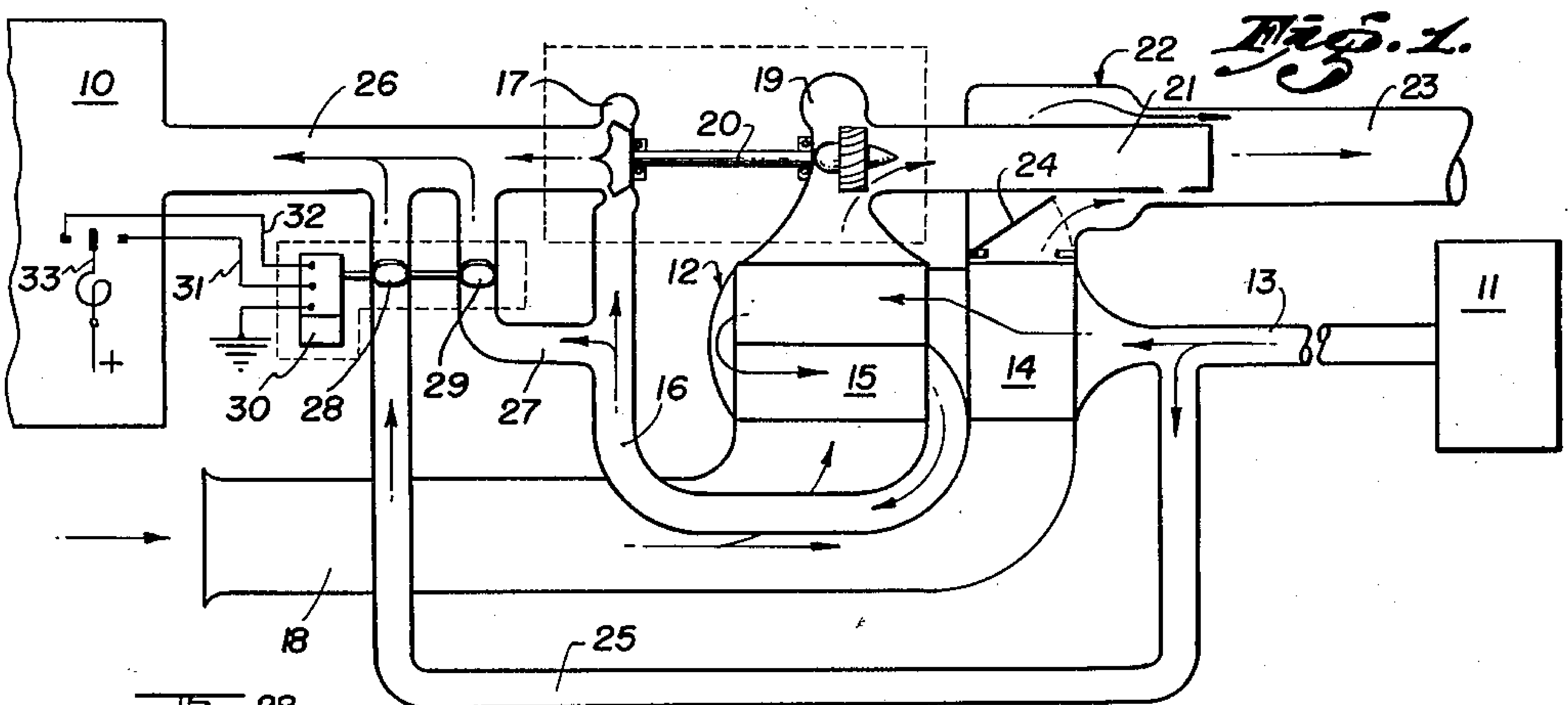


Fig. 2.

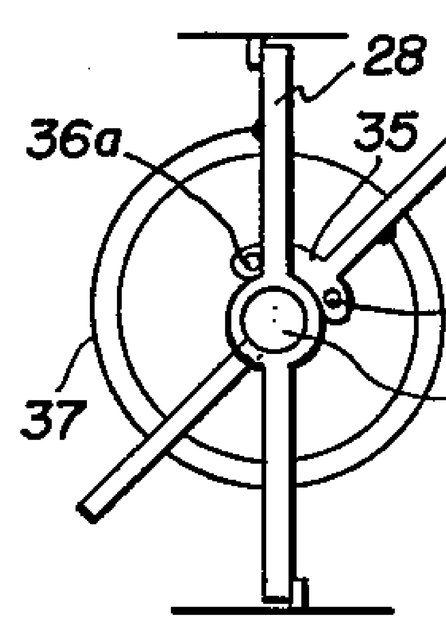


Fig. 3.

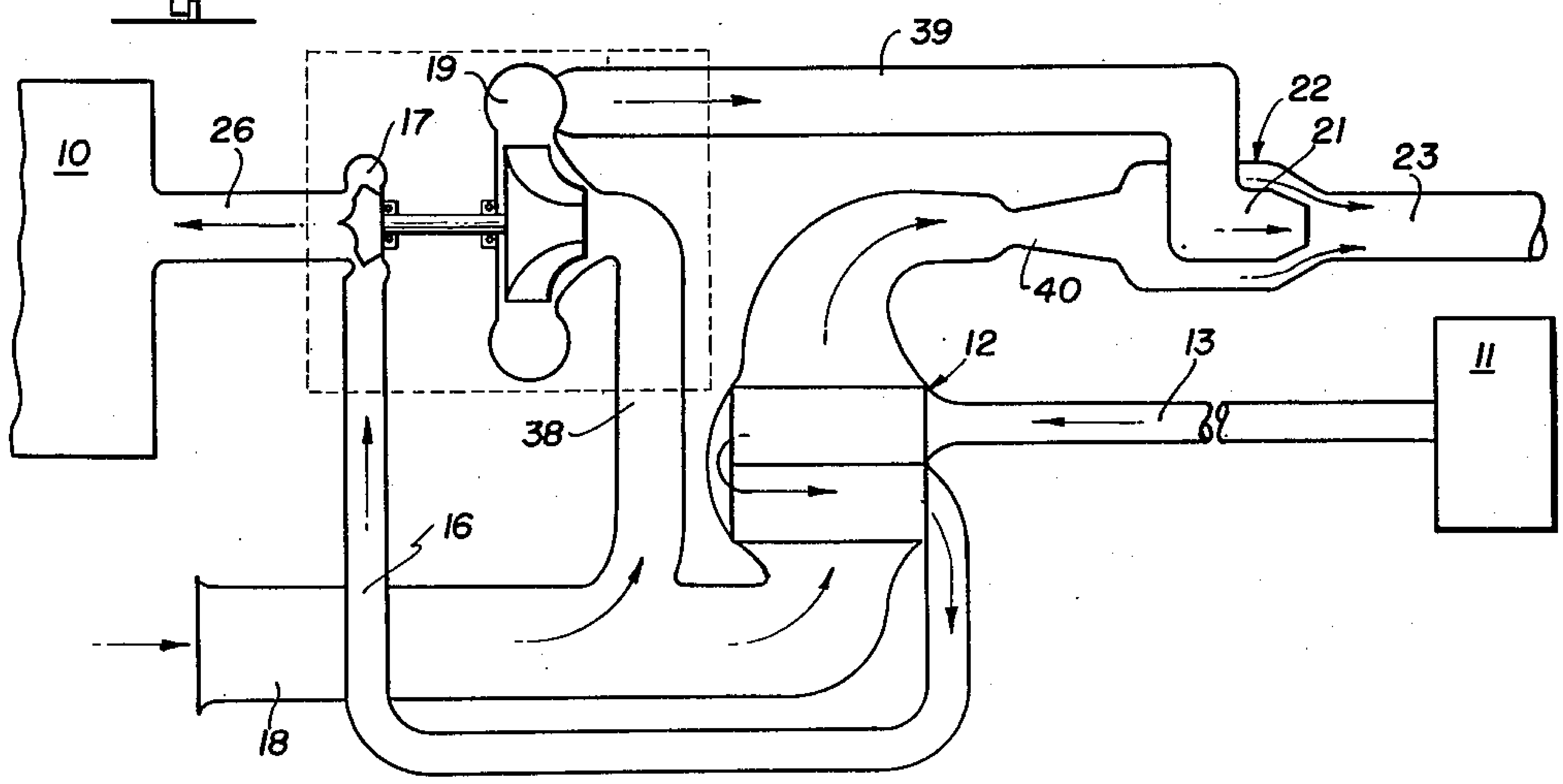
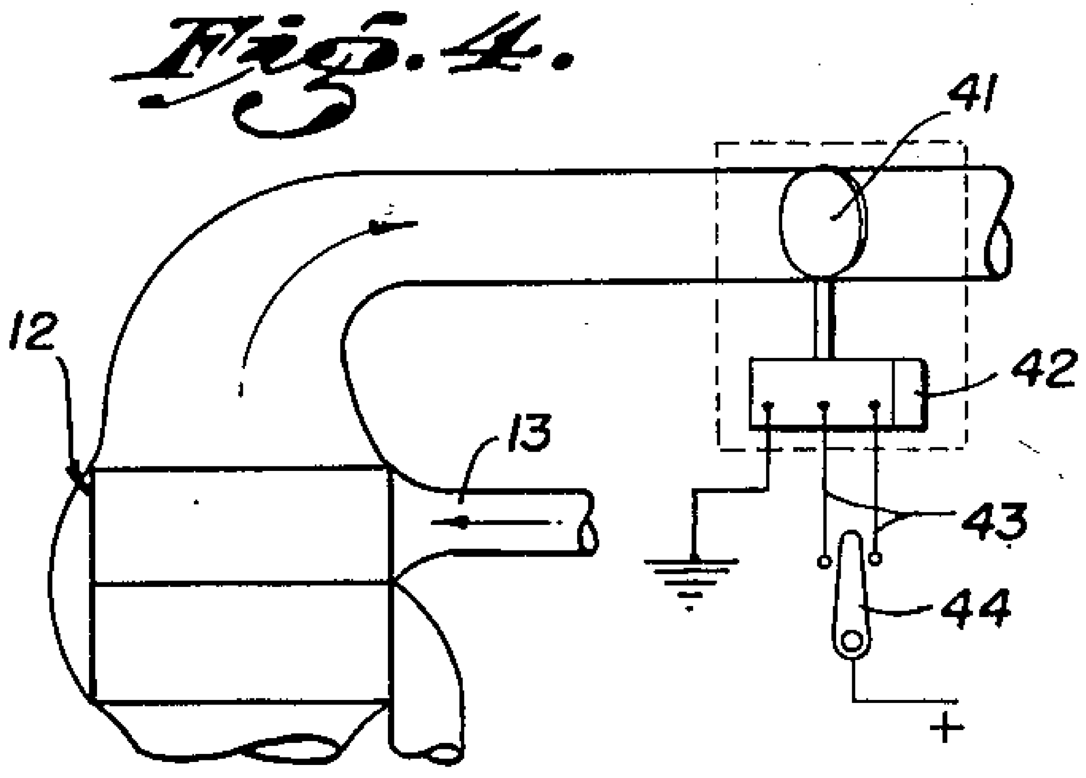


Fig. 4.



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AIR CONDITIONING MEANS FOR ENCLOSURES

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15 Claims. (Cl. 62—6)

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The present invention relates generally to air conditioning means for conditioning the air of an enclosure; and is concerned particularly with such means for cooling or refrigerating air for the cabin or other compartments of aircraft.

It is one object of the herein described invention to provide air conditioning means, wherein power means such as a cooling turbine may be utilized for converting energy of the enclosure conditioning air into mechanical energy, and this recovered energy utilized to drive coolant air circulating means which is connected so as to discharge its output into an aspirator for creating a suction on the downstream side of the coolant air path of a heat exchanger.

A further object is to provide a cooling system for an enclosure, wherein a single heat exchanger of unitary construction may be utilized having a primary section and a secondary section, and in which power means driven by enclosure conditioning air drives coolant air circulating means for one section of the heat exchanger, and the discharge from the coolant air circulating means is conducted to an aspirator for aspiration of coolant air through the other section of the heat exchanger.

Another object is to provide air conditioning means in which the output discharge of an air circulating mechanism is utilized in a suitable device, such as an aspirator, for creating a suction for the circulation of other air for a useful purpose, for example, the coolant air for a heat exchanger, and wherein the actuating air and aspirated air leaving the aspirator are mixed and discharged through a single duct rather than a plurality of ducts.

Still another object is to provide in connection with air conditioning means embodying a power driven air moving unit, such as a compressor unit, an aspirator in the compressor output for effecting circulation of other air, and which will at the same time serve as a load regulating device on the compressor unit.

Further objects of the invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing several embodiments of the invention without placing limitations thereon.

Referring to the accompanying drawings, which are for illustrative purposes only:

Fig. 1 is a view schematically illustrating cooling mechanism embodying the features of one form of the herein described invention;

Fig. 2 is a detail view diagrammatically illustrating the interconnection between the by-pass control valves of the present invention;

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Fig. 3 is a similar view of a modified form of the invention; and

Fig. 4 is a fragmentary view showing a variation of the means for controlling the discharge flow of coolant air from the heat exchanger.

Referring now to the drawings, for purposes of illustration several embodiments of the invention have been illustrated. In its broad concept, the invention may be utilized for the conditioning of air for enclosures generally, but is particularly useful for the conditioning or refrigeration of air in the compartments of aircraft, which may be of the pressurized or unpressurized type.

The embodiment disclosed in Fig. 1 is illustrative of an arrangement for supplying conditioning air to a pressurized compartment 10 which may be the cabin of an aircraft. The conditioning air is supplied from a pressure air source 11 to a heat exchanger 12 wherein the conditioning air is brought into heat exchange relation with a fluid coolant.

Air is supplied from the pressure air source 11 to the heat exchanger 12 through a duct 13 through which the flow of air may be controlled and regulated by sensing responsive devices (not shown) depending upon the design requirements of the compartment of the airplane.

The heat exchanger 12 is illustrated as a single unit having a primary section 14 and a secondary section 15. The conditioning air flows through the primary section in a single pass, but is conducted through a secondary section in a double pass. The conditioning air discharge from the heat exchanger is connected through a duct 16 with the inlet of energy converting means 17 which in this instance comprises an expansion turbine which acts to further cool the conditioning air and convert energy of the conditioning air into mechanical energy for power or other useful purpose. The outlet of the energy converting means 17 is connected with the compartment 10.

Coolant fluid is supplied to the heat exchanger from a suitable source, which in this instance is illustrated as comprising a ram duct 18 which is connected with the coolant inlet side of the primary section 14 and secondary section 15 of the heat exchanger.

The outlet side for coolant of the secondary section of the heat exchanger connects with the inlet of air moving means 19, in this instance a fan having its impeller directly connected for drive from the energy converting means 17 by means of a transmission shaft 20.

The outlet from the air moving means is directed through a discharge duct 21 which in effect forms the nozzle of an aspirator, as generally indicated by the numeral 22, the discharge duct being surrounded by a concentrically positioned mixer duct 23. The inlet end of the mixer duct is connected to receive the discharge of coolant fluid from the primary section 14 of the heat exchanger, and the outer end of the mixer duct is carried to a discharge point where the coolant fluid is discharged overboard or otherwise disposed of.

Reverse flow of coolant fluid through the primary section 14 of the heat exchanger is prevented under certain conditions of operation by means of a check valve 24 which is mounted in the connection of the coolant discharge of the primary section 14 with the aspirator. Primarily, the check valve 24 provides means for blocking the primary heat exchanger coolant passage when the air conditioning means is operated on the ground, in which case the ram duct 18 is ineffective.

Means are provided for controlling the temperature of the conditioning air in accordance with the temperature variations of the compartment 10. This is accomplished through the utilization of a plurality of controlled by-pass ducts. As shown in Fig. 1, one of these ducts, as indicated by the numeral 25, is connected at its inlet end with duct 13 upstream from the heat exchanger 12, and at its outlet end with a duct 26 which connects the outlet of the energy converting means 17 with the compartment 10. The duct 25 therefore by-passes the heat exchanger and energy converting means so as to conduct conditioning air of relatively higher temperature to the compartment.

The other by-pass duct, as indicated by the numeral 27, is connected around the energy converting means 17 only, the inlet end of the by-pass duct 27 being connected to the duct 16 and the outlet end being connected to the duct 26. In some installations, it may be found desirable to leave out one or the other of the ducts 25 and 27.

Flow control through the ducts 25 and 27 is controlled by means of a pair of butterfly valves 28 and 29, mounted respectively in the by-pass ducts 25 and 27. These valves are actuated by a common torque actuator 30, the direction of which is controlled through circuit connections 31 and 32 which are selectively energized by a temperature sensing device 33 in the compartment 10.

The valves 28 and 29 are arranged to proportionally control the flow of air through the by-pass ducts, and are usually arranged with a predetermined angular lag in the time of full closing of one valve with respect to the time of closing of the other valve.

In the arrangement described herein, the valve 29 is arranged to open prior to the opening of valve 28. This is accomplished by having one of the valves coupled directly to the actuator, and providing a lost motion connection with the other valve. Such a connection is diagrammatically illustrated in Fig. 2, wherein the valve 29 is shown as being directly connected with an actuator shaft 34 for concerted rotational movement therewith. The valve 29 is shown as having a disc 35 connected for movement therewith, relative angular displacement of valves 28 and 29 being limited by limit studs 36a and 36b which permit displacement of one valve with respect to the other through an angle of substantially 45°. A loading spring 37 normally biases the valve 28 towards an angular position with respect to the valve 29. With this arrangement, it will be apparent that with both valves in closed position, the valve 28 will remain closed until the valve 29 has been moved in an opening direction through an angle of substantially 45°. It will be appreciated that the angular relationship between the valves 28 and 29, need not be limited to 45° but may be made some other angle if desired. Moreover, the connection may be arranged so that the angular displacement between the opening and closing of the valves may be adjustable.

In the arrangement described above, the air moving means 19 comprises a low head compressor or fan, and the operation of the aspirator 22 may vary depending upon the conditions of operation. For example, under no-ram or low-ram conditions of operation, a pressure adjacent the discharge end of duct 21 slightly in excess of pressure existing at the coolant inlet to the primary section of the heat exchanger will cause the aspirator to function as such. Thus, the operation will be somewhat different in different installations due to duct losses, etc.

Under high-ram conditions, wherein the pressure at the coolant inlet of the primary section of the heat exchanger is much higher than the pressure adjacent the discharge end of the duct 21, the aspirator functions more as a mixer than as a true aspirator.

The conditioning means described above is advantageous in that it permits use of a turbine-fan assembly of smaller weight, height and size than that which would ordinarily be required, so that where the conditioning means is provided as a refrigerating package, the material size physically of the package is reduced. Moreover, the utilization of an aspirator as explained above permits building a multi-section primary and secondary heat exchanger as a single unit utilizing one discharge duct.

Referring to Fig. 3, the arrangement disclosed therein is primarily a simple system embodying the features of the invention, and while considered herein primarily for the supplying of conditioning air to an unpressurized compartment or enclosure, it is not limited to this particular use, and may under proper conditions be utilized for pressurized enclosures. Similar parts, corresponding to the parts of the arrangement shown in Fig. 1, have been given the same indicating numeral.

The arrangement of Fig. 3 differs basically from that shown in Fig. 1, in that the air moving means 19 in this case has its intake supplied directly from the ram duct 18 through a supply duct 38, and has been illustrated as a true compressor. The outlet of the air moving means 19 is connected through an outlet duct 39 to the discharge duct 21 which in this case comprises the nozzle of the aspirator.

It will be appreciated that the aspirator can pump only very low heads, and that for this reason pressure losses in the coolant circuit must be kept at a minimum for those conditions in which no-ram is available.

The present invention contemplates a restricting device in the coolant circuit to prevent excessive coolant air flow when high-ram pressures are available, but will have practically no pressure losses, when ram is not available.

In the arrangement shown in Fig. 3, a venturi 40 is positioned in the discharge duct for coolant from the heat exchanger 12. This venturi is connected with the outer mixer duct of the aspirator and allows adequate flow of coolant under no-ram conditions, yet functions to restrict flow under high-ram conditions so as to prevent excessive flow of coolant air and thus minimize undesirable drag on the aircraft.

Instead of utilizing a venturi, as shown in Fig. 3 for automatically controlling the flow of coolant through the heat exchanger 12, the coolant flow may be controlled by a valve, such as indicated in Fig. 4 by the numeral 41, this valve being actuatable by a torque actuator 42 which is selectively operable through a circuit 43 by means of a control switch 44. The control switch 44 may form a part of a control device arranged for thermostatic actuation, pneumatic actuation or other suitable means. If desired, the valve 41 may be manually operated. By utilizing a valve instead of a venturi, the coolant drag is minimized, since a greater flow restriction is possible under high-ram conditions without exceeding the low heads which can be developed by the aspirator under no-ram conditions.

The utilization of an aspirator 22, as described in the arrangement disclosed in Fig. 3, provides the additional advantage of regulating the speed of the turbo-compressor unit. Should the turbine tend to increase its speed, this increased speed will cause the compressor to build up pressure in the aspirator nozzle, and as a result additionally loads the turbine and prevents overspeeding. Conversely, should the turbine tend to slow down, the pressure in the aspirator nozzle is correspondingly reduced so that the load on the turbine is decreased, whereupon the decrease in turbine speed will be minimized. It will therefore be seen that the aspirator additionally functions to regulate the speed of the turbo-compressor unit.

I claim:

1. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; air circulating means driven by said energy converting means; means actuated by air from the air circulating means for inducing flow of said coolant; a by-pass duct for flow of conditioning air around the heat exchange means and the energy converting means; a separate by-pass around the energy converting means; and valve means for proportionally controlling the air flow in said by-passes in response to temperature variations within said enclosure.

2. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; air circulating means driven by said energy converting means; means actuated by air from the air circulating means for inducing flow of said coolant; a by-pass duct for flow of conditioning air around the heat exchange means and the energy converting means; a separate by-pass around the energy converting means; and means for controlling the air flow in said by-passes in response to an air conditioning requirement of said enclosure.

3. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path having a single pass primary section and a multiple pass secondary section for said conditioning air; a turbine in said flow path downstream from said heat exchanger; a fan driven by said turbine; concentric inner and outer tubular members forming an aspirator and mixing duct; a ram source of coolant air; branch ducts from said source, one of said branch ducts being connected through said secondary section and said fan to said inner tubular member, and the other branch duct being connected through said primary section to said outer tubular member; and a check valve in said latter branch duct between said primary section and the outer tubular member operable to closed position upon a predetermined reduction of flow.

4. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path having a primary section and a secondary section; a turbine in said flow path downstream from said heat exchanger; a fan driven by said turbine; concentric inner and outer tubular members forming an aspirator and mixing duct; a ram source of coolant air; branch ducts from said source, one of said ducts being connected through said secondary section and said fan to said inner tubular member, and the other branch duct being connected through said primary section to said outer tubular member; and a check valve in said latter branch duct between said primary section and the outer tubular member operable to closed position upon a predetermined reduction of flow.

5. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path; a turbine in said flow path downstream from said heat exchanger; a compressor driven by said turbine; an aspirator having a nozzle for primary air and a suction connection; a ram source of coolant air; branch ducts from said coolant air source, one of said ducts being connected through said compressor to said nozzle, and the other of said ducts being connected through said heat exchanger to said suction connection, whereby coolant air is sucked through the heat exchanger in heat exchange relation to the enclosure conditioning air; and a venturi in said latter branch duct between the heat exchanger and aspirator suction connection.

6. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path; a turbine in said flow path downstream from said heat exchanger; a compressor driven by said turbine; an aspirator having a nozzle for primary air and a suction connection; a ram source of coolant air; branch ducts from said coolant air source, one of said ducts being connected through said compressor to said nozzle, and the other of said ducts being connected through said heat exchanger to said suction connection, whereby coolant air is sucked through the heat exchanger in heat exchange relation to the enclosure conditioning air; and means in said latter branch duct between the heat exchanger and aspirator suction connection for varying flow therein.

7. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path; a turbine in said flow path downstream from said heat exchanger; a compressor driven by said turbine; an aspirator hav-

ing a nozzle for primary air and a suction connection; a ram source of coolant air; and branch ducts from said coolant air source, one of said ducts being connected through said compressor to said nozzle, and the other of said ducts being connected through said heat exchanger to said suction connection, whereby coolant air is sucked through the heat exchanger in heat exchange relation to the enclosure conditioning air.

8. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger in said flow path; a turbine in said flow path downstream from said heat exchanger; a compressor driven by said turbine; an aspirator having a nozzle for primary air and a suction connection; a source of coolant air; and branch ducts from said coolant air source, one of said ducts being connected through said compressor to said nozzle, and the other of said ducts being connected through said heat exchanger to said suction connection, whereby coolant air is sucked through the heat exchanger in heat exchange relation to the enclosure conditioning air.

9. Air conditioning means for an enclosure comprising: a flow path for conducting conditioning air to said enclosure; a heat exchanger for bringing the conditioning air into heat exchange relation with air from a coolant air source; a cooling turbine in the conditioning air flow path; an air moving device driven by said turbine having an inlet connection with the coolant air source and an outlet connection with a discharge duct; and a concentrically spaced duct surrounding the discharge end of said discharge duct and having an inlet flow connection with said coolant air source including said heat exchanger, whereby air discharge from the discharge duct is mixed with coolant air from the heat exchanger.

10. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; air circulating means driven by said energy converting means; and an aspirator having a nozzle connected to receive air from the air circulating means, and a suction connection with said heat exchange means for inducing flow of said coolant therethrough.

11. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; air circulating means driven by said energy converting means; and means actuated by air from the air circulating means for inducing flow of said coolant.

12. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; heat exchange means for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; and means actuated by said energy converting means for circulating said coolant through the heat exchanger, said circulating means including means for regulating the load imposed on said energy converting means.

13. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; heat exchange means for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; and means actuated by said energy converting means for circulating said coolant through the heat exchanger, including means for regulating the load on said energy converting means in response to speed variations.

14. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; means for converting energy of the conditioning air into mechanical energy; air circulating means driven by said energy converting means; and aspirator means actuated by air from said air circulating means for inducing flow of said coolant and regulating the speed of said energy converting means.

15. Air conditioning means for an enclosure, comprising: a flow path for conducting conditioning air to said enclosure; means in said path for bringing the conditioning air into heat exchange relation with a coolant; a coolant source; an aspirator having a nozzle connection and a suction connection respectively with said coolant source, said suction connection including said heat exchanger means; and means driven by conditioning air for circulating coolant air through said nozzle, whereby coolant flow is induced through said heat exchanger means.

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