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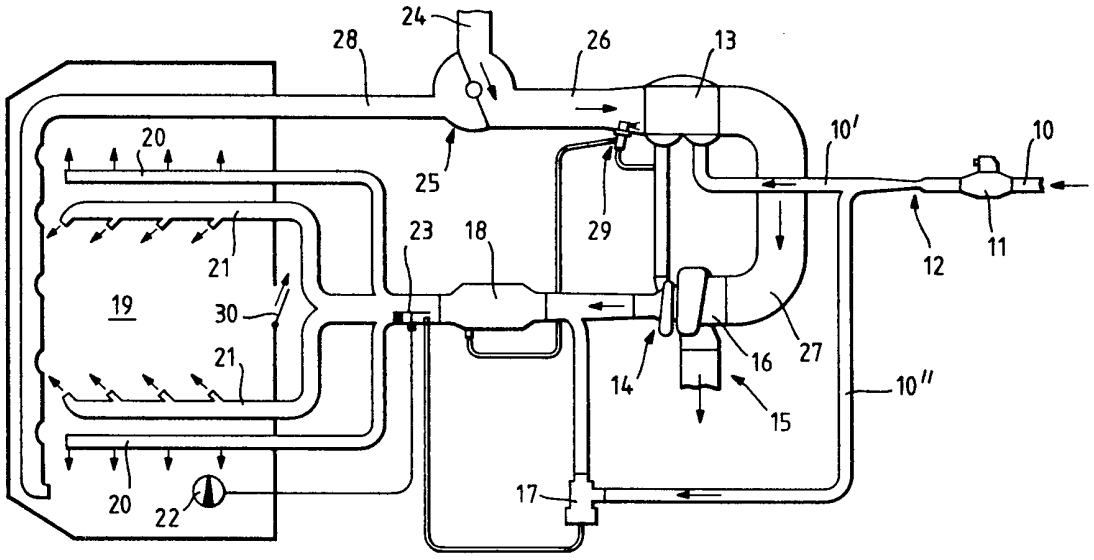
(54) Air conditioning systems for aircraft cabins

(57) Pressurised air from the aircraft engine compressor is supplied *via* a duct 10 and a heat exchange 13, to an expansion turbine 14 which drives a fan 16 which assists the flow of ram air from an intake 24 through the heat exchanger. The cooled, pressurised air is fed to the cabin 19 via a water extractor 18 and demist ducts 20 and ventilation ducts 21. Air leaves the cabin via a valve 30. A selector valve 25 normally is set so that all the coolant air for the heat exchanger is drawn from the ambient air duct 24. When, however, the pressure or volume of the cooled, pressurised air is insufficient, the selector valve is set so that air is drawn from the cabin through a duct 28, thereby increasing circulation of air through the cabin. In a third position of the valve 25, only ram air is supplied to the cabin.

Fig. 1.



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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1.

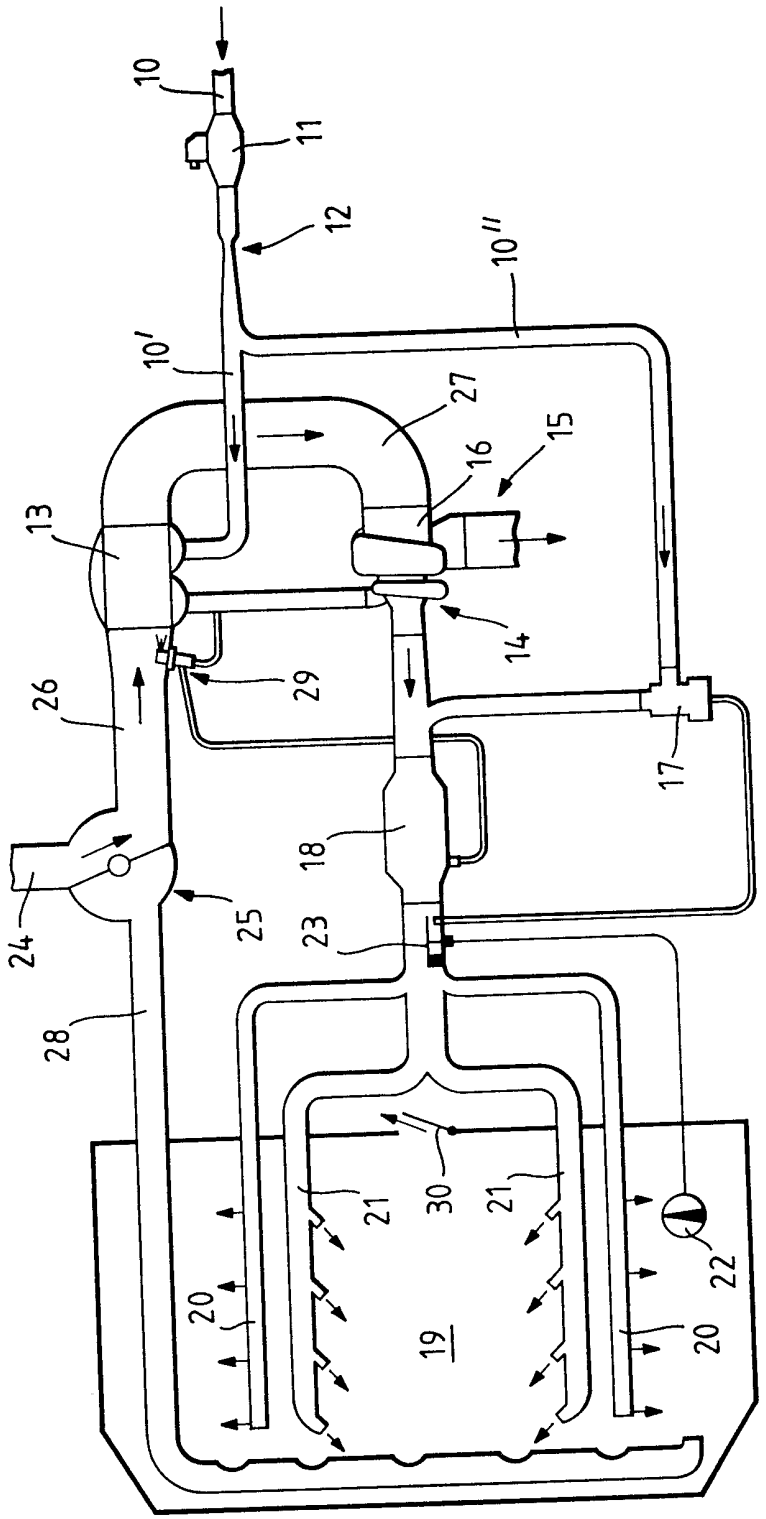

Fig.2.

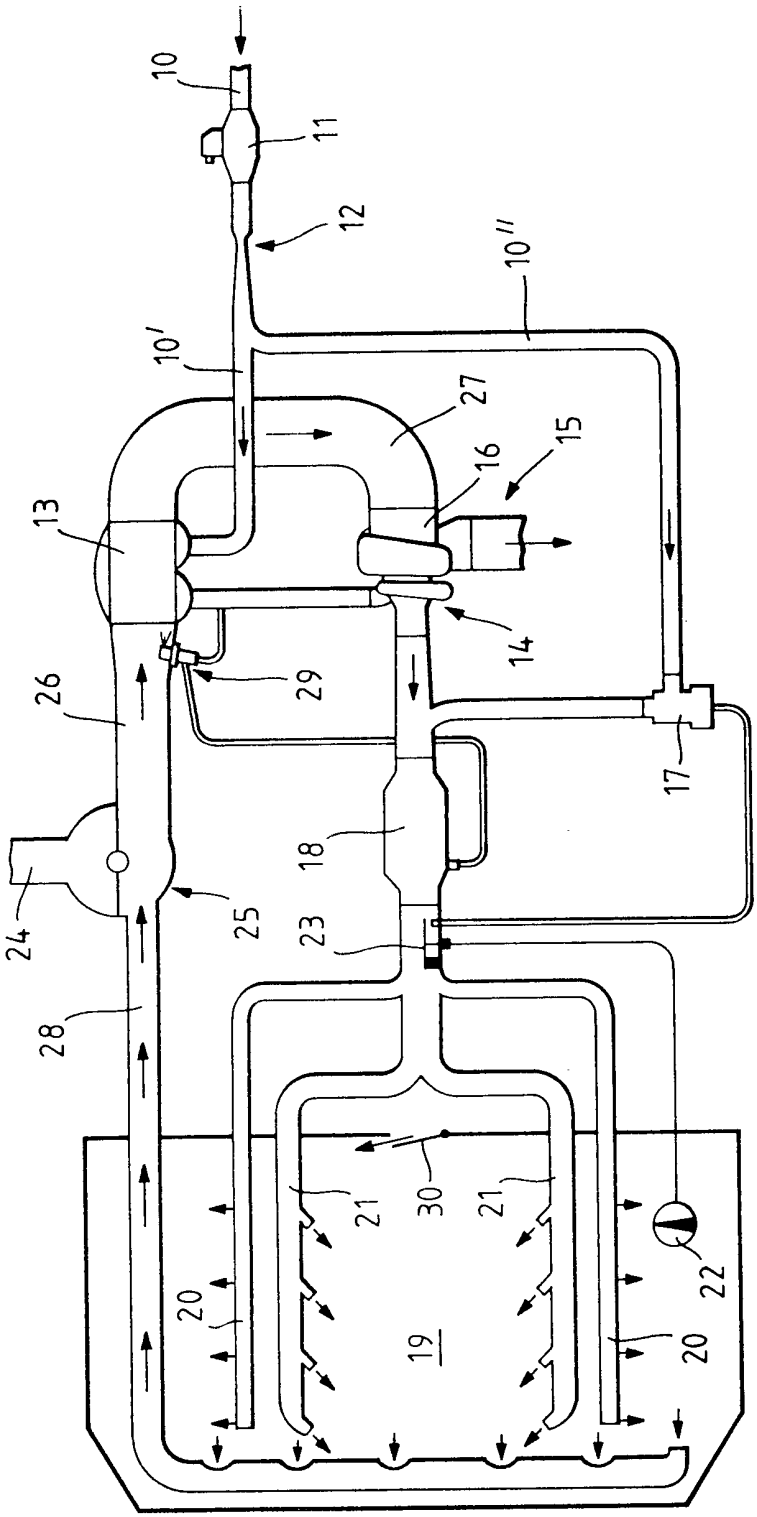
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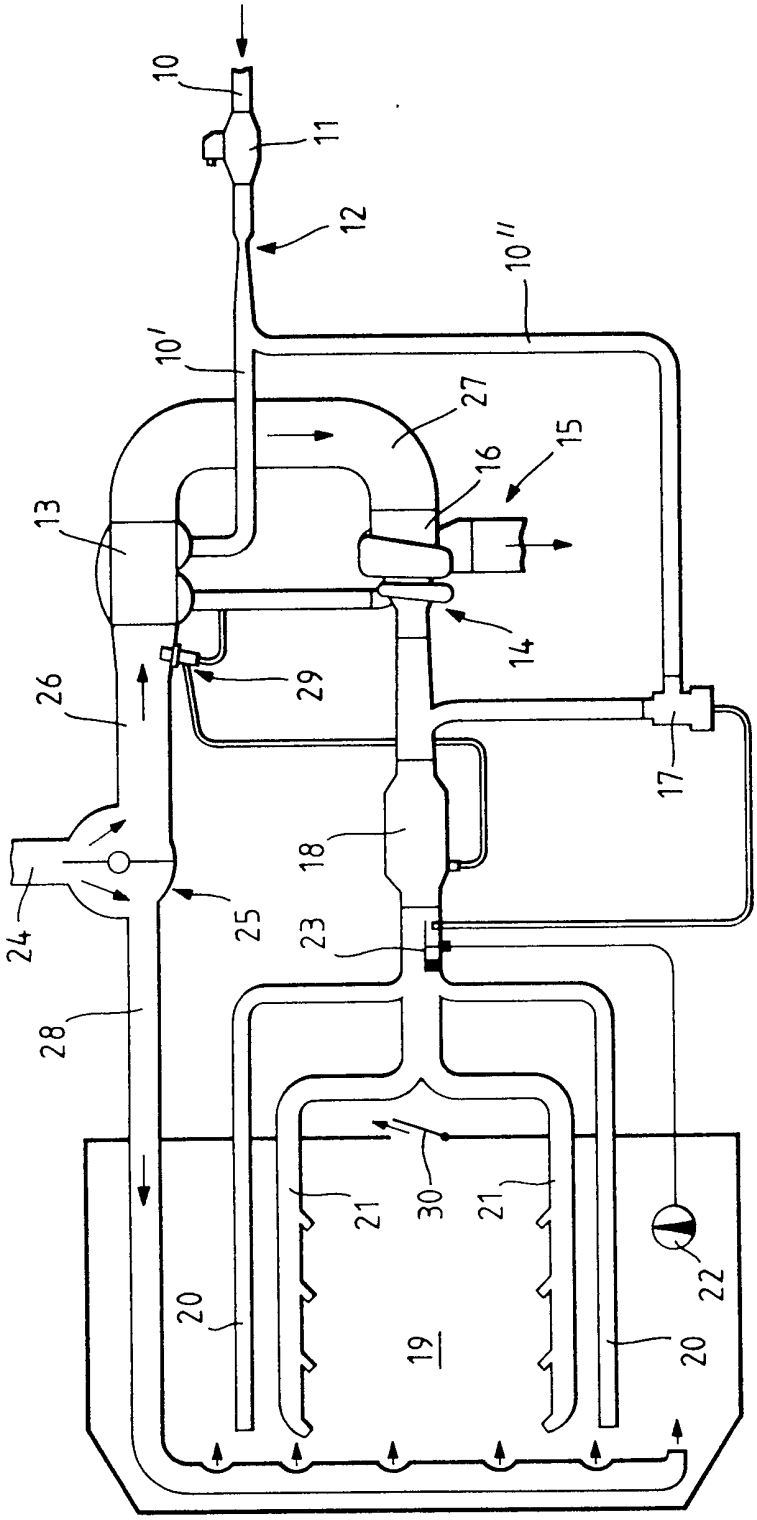
Fig.3.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SPECIFICATION

Air conditioning systems

This invention relates to air conditioning systems and in particular, though not exclusively, to air conditioning systems for cooling the cabin of an aircraft.

In many known cooling systems for aircraft having one or more gas turbine powerplants, high pressure air is bled from the compressor of the powerplant, cooled in a heat exchanger supplied with cold ambient air by means of a ram air intake, expanded in a turbine, and then supplied to the aircraft cabin, after mixing with pressurised air direct from the compressor to adjust the air temperature if necessary. This type of system is normally matched to the aircraft cruise condition, insofar as the pressure and flow rate of the air bled from the compressor are concerned. Thus it will be understood that when the aircraft powerplant is set at ground idle, the pressure and flow rate of the air available from the compressor may be insufficient to allow adequate cockpit cooling and ventilation. It would of course be possible to provide a second independent system to cater for this condition but only at added cost and weight.

In this specification, when referring to a heat exchanger the term "charge" side is used to mean that side of the heat exchanger which receives charge fluid at a high temperature and from which charge fluid leaves at a lower temperature, and the "coolant" side is the side of the heat exchanger which receives coolant fluid at low temperatures and from which the coolant fluid leaves at a higher temperature.

According to one aspect of this invention, there is provided an air conditioning system for supplying conditioned air to a generally enclosed region, including a source of pressurised charge air, heat exchange means having a charge side and a coolant side in heat exchange relationship, means for supplying said charge air to the charge side of the heat exchanger, thereby to cool said charge air, means for supplying said cooled charge air to an expansion means thereby further to cool the air, means for delivering said further cooled air to said region, coolant duct means for supplying coolant air to said coolant side, means adapted to cause coolant air to flow through said coolant side, selector valve means associated with said coolant duct, ambient air duct means for supplying ambient air to said selector valve means and further duct means for supplying air from said region to said selector valve means, said selector valve means being operable to select the source from which said coolant air is taken.

In normal conditions, the selector valve will be set to cause the coolant air to be taken from the ambient air; when however the pressure or flow rate of the source of pressurised charge air is reduced, the selector valve may be set to select air from the generally enclosed region, thus increasing the circulation of air through the region.

If for any reason there is no supply of pressurised air, the selector valve may be set so that the ambient air duct means supplies air to the further duct means thereby to effect ventilation of the region.

Preferably, said expansion means comprises an expansion turbine and the means adapted to cause cooling air to flow comprises a fan, preferably driven by said turbine.

By way of example only, one specific embodiment of air conditioning system for an aircraft will now be described reference being made to the accompanying drawings, in which

Figure 1 is a schematic view of the air conditioning system in a first operating condition;

Figure 2 is a schematic view of the system of Fig. 1 in a second operating condition; and

Figure 3 is a schematic view of the system of Fig. 2 in a third operating condition.

The system illustrated in the figures is intended for use in an aircraft having a gas turbine powerplant in which a limited supply of pressurised air may be bled from the powerplant compressor. The aircraft includes a cabin in which it is wished to maintain a conditioned environment. The system includes a charge air path and a coolant air path and the paths will be described in this sequence.

Referring initially to the charge air path, the air conditioning system includes a duct 10 supplying air bled from the powerplant compressor to a pressure regulating shut off valve 11 whence the pressurised air passes through a venturi 12 which serves to limit the flow through the system. Downstream of the venturi, the duct divides, one branch 10' supplying pressurised air to the charge side of a heat exchanger 13 and the other branch 10" supplying pressurised air to a temperature control valve 17 for purposes to be described below.

From the charge pass of the heat exchanger 13, the cooled pressurised charge air passes to the turbine 14 of a cold air unit 15, where the air is expanded and thus further cooled. The turbine 14 drives a fan 16 thereby to absorb the energy extracted from the air on expansion thereof. On leaving the turbine 14, the further cooled air passes via a water extractor 18, into the cabin 19. The air is routed into and around the cabin by means of canopy demist ducts 20 and ventilation ducts 21. Temperature control of the air entering the cabin is effected by means of the temperature selector 22 located within the cabin which, in conjunction with temperature sensor 23 located immediately downstream of the water extractor 18, signals the temperature control valve 17 to mix the appropriate amount of relatively hot by-pass air from duct 10" with

the air exhausted from the turbine 14.

Referring now to the coolant path the aircraft is provided with a ram air intake 24 which supplies coolant air to a three-way selector valve 25. A coolant duct 26 connects the selector valve 25 to the coolant side of the heat exchanger 13, and a further duct 27 connects the coolant side with the fan 16. A cabin air duct 28 connects the interior of the cabin 19 to the three-way selector valve 25. Water drained from water extractor 18 is supplied by a pipe to an aspirator device 29 which is lcoated in the coolant duct immediately upstream of the heat exchanger 13 and which sprays water into the heat exchanger inlet thereby effectively to reduce the temperature of the air admitted to the coolant side of the heat exchanger. Flow of coolant air through the heat exchanger 13 is assisted by means of the fan 16 which is driven by the turbine 14; the fan efflux is exhausted overboard.

The operating condition shown in Fig. 1, known as the ECS mode, is the normal mode for when the aircraft is in flight, but may also be employed when the aircraft is on the ground if the cooling available is sufficient for the prevailing ambient conditions. In this mode engine bleed air only is supplied to the cockpit.

In this mode the three-way selector valve 25 is set so that the coolant duct receives coolant air from the ram air duct 24 alone and pressurised change air bled from the engine compressor passes through the heat exchanger 13 where it is cooled and thence to the turbine 14 where it expands and thus further cools and at the same time gives up mechanical work which is absorbed by the fan 16. After being further cooled, the air charge passes into the cabin 19 *via* the water extractor 18. In this mode therefore, the only air that it introduced into the cabin is the charge air bled from the powerplant, and air leaves the cabin *via* the pressure balance valve 30.

Referring now to the operating condition shown in Fig. 2, this is known as ECS with augmented ground ventilation. In this condition air is bled from the engine, cooled, expanded and passes into the cabin, as in the ECS mode. However, when the powerplant is at "ground idle" setting, the bleed air pressure and flow available may be insufficient to provide adequate cabin cooling and ventilation.

In order to improve the system performance under these conditions, the cabin ventilation is increased by setting the three way selector valve 25 so that the coolant duct draws all its air from the cabin air duct instead of from the ambient air duct. The effect of this is that further ambient air is drawn directly into the cabin *via* vent 30 to provide augmented ventilation. Thus the air supplied to the cabin is a combination of air supplied from the powerplant compressor, and that drawn in from outside, and the throughput of air through the cabin is typically 3 to 4 times greater than that if the system were in the ECS only mode.

This method obviates the need for additional ventilation fans with the consequent drain on electrical power. This feature is particularly useful for purging hot air from the cabin after the aircraft has been standing in the sun for a long period and the cabin temperature is consequently well above ambient.

Referring finally to the operating condition shown in Fig. 3 this is known as the Ram Air only mode, and is used when there is no pressurised air supplied to the turbine either by choice or malfunction. In this mode the three way selector valve 25 is set so that the air from the ram air duct 24 is supplied both to the cabin air duct 24 and the coolant air duct 26. The only air entering the cabin in this mode is that passing along the cabin air duct, air leaving the cabin via the pressure balance valve 30.

Ram air is supplied to the coolant air duct 26 in this mode to prevent overspeeding of the turbine 14 should the engine bleed air be inadvertently switched on with the fan 16 in a stalled condition.

It will be appreciated that judicious siting of the ram air duct, for example in the slipstream of the aircraft propeller, significantly increases airflow in the cabin in the Ram Air only mode.

Whilst the above system has been described with reference to an aircraft having an unpressurised cabin, it will be appreciated by those skilled in the art that it may readily be adapted for use in aircraft having pressurised cabins.

CLAIMS

1. An air conditioning system for supplying conditioned air to a generally enclosed region, including a source of pressurised charge air, heat exchange means having a charge side and a coolant side in heat exchange relationship, means for supply charge air to the charge side of the heat exchanger thereby to cool said charge air, means for supplying said cooled charge air to expansion means thereby further to cool the air, means for delivering said further cooled air to said region, coolant duct means for supplying air to said coolant side, means adapted to cause coolant air to flow through said coolant side, selector valve means associated with said coolant duct, ambient air duct means for supplying ambient air to said selector valve means, and further duct means for supplying air from said region to said selector valve means, said selector valve means being operable to select the source from which said coolant air is taken.

2. An air conditioning system according to claim 1, wherein said expansion means comprises an expansion turbine.

3. An air conditioning system according to claim 1 or claim 2, wherein said means

adapted to cause coolant air to flow comprises a fan.

4. An air conditioning system according to claim 2 and claim 3 wherein said expansion turbine is drivably connected to said fan.

5. An air conditioning system, substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

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