

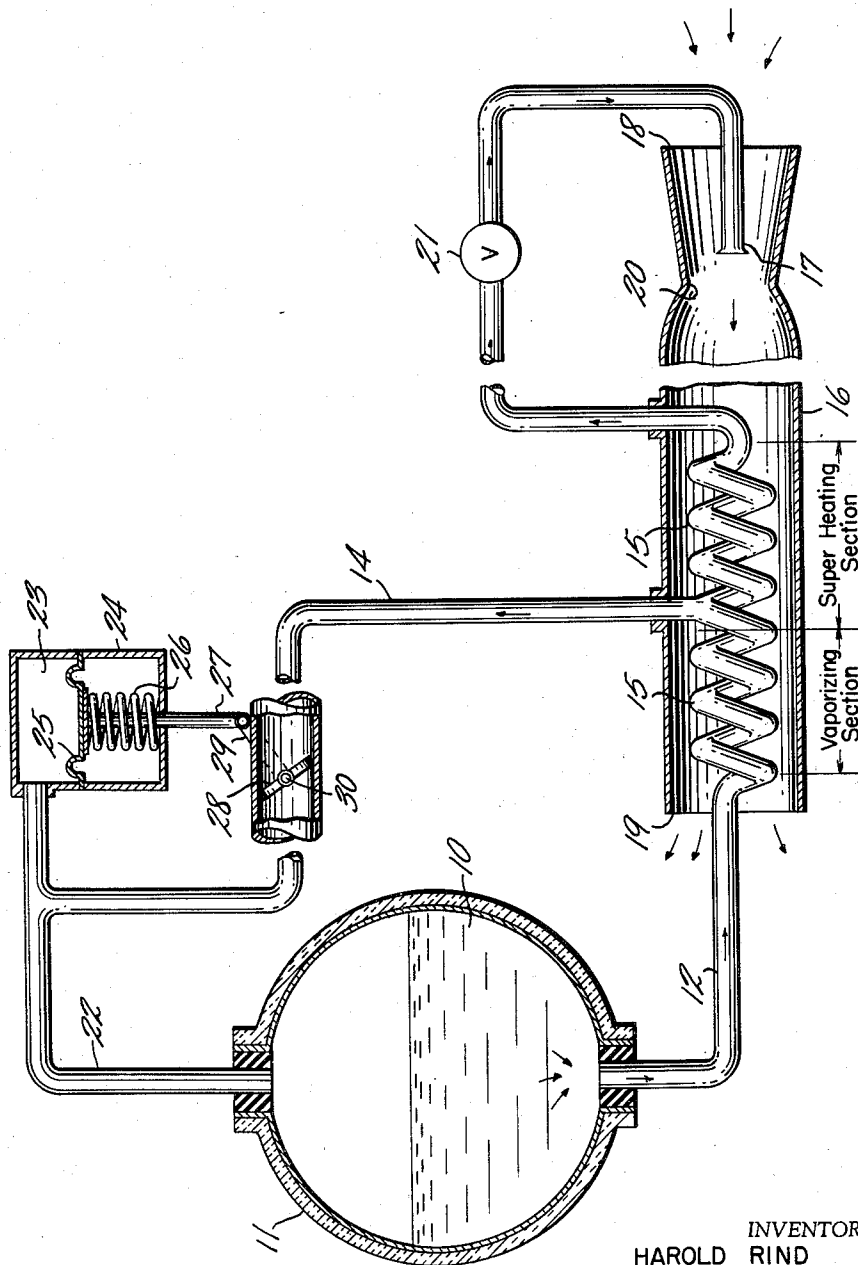
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AIR CONDITIONING SYSTEM

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AIR CONDITIONING SYSTEM

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This invention relates to an air conditioning system in which the air within a fully or partially enclosed space is cooled by a liquefied gas, such as liquid air or oxygen. The air conditioning system is relatively simple, lightweight, and particularly suited for conditioning the air within the cabin of an airplane or spaceship.

More specifically, the air conditioning system of the present invention provides an air conditioning and cooling passage in communication with the space to be air conditioned. A flow of air is induced through this air conditioning and cooling passage by introducing into the passage a high velocity stream of a relatively cool gaseous fluid, preferably a harmless gaseous fluid containing a mixture of oxygen and nitrogen. This cooling fluid is stored at low temperature in the liquid state, and before it is introduced into the air cooling passage, it is brought into heat exchange relationship with the air flowing through the air conditioning and cooling passage. The exchange of heat between the two fluids vaporizes the liquefied gas, thus cooling the air flowing through the passage. The vaporized fluid is then introduced into the cooling passage and, by virtue of its oxygen content and relatively low temperature, it conditions and further cools the air within the enclosed space.

An ancillary feature of the air conditioning system is the means for regulating the pressure in the vapor region of the storage container for the liquefied gas.

For a more complete understanding of the present invention, reference may be made to the detailed description which follows and to the accompanying drawing in which the air conditioning system is shown diagrammatically in a cross-sectional view.

Referring to the drawing, a liquefied gas 10, such as liquid air or oxygen, is stored in an insulated container 11. The temperature of liquid oxygen is about 297° F. or below, and the temperature of liquid air is about 312° F. or below. The liquefied gas, sometimes hereinafter called the regnant fluid, is fed by gravity and by the pressure of the gas in the upper region of the container through a conduit 12 which is formed with a plurality of coils 15 in which the liquid is vaporized and superheated. In the drawing, the vaporizing and superheating lengths of the coils are labeled. The fluid, now in the superheated gaseous state, is discharged through an ejector nozzle 17 into an air conditioning and cooling conduit 16.

Both ends of the conduit 16 are in communication with the space to be air conditioned. The discharge of the regnant fluid through the ejector nozzle 17 just upstream of the throat portion of the ejector 20 induces a flow of the air, sometimes hereinafter called the subject fluid, through the conduit 16 from the inlet end 18 to the discharge end 19 thereof.

The coils 15 of the conduit 12 are accommodated within the conduit 16 downstream of the ejector 20 thereof, so that the liquid air or oxygen flowing through the coils 15 is in out-of-contact heat exchange relationship with the air which flows through the conduit 16. Thus, heat is transferred from the subject fluid to the regnant fluid,

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or in other words, from the air flowing through the conduit 16 to the liquid within the coils 15. This exchange of heat cools the air flowing through the conduit 16 and vaporizes and superheats the liquid flowing in counter-current fashion through the coils 15 of the conduit 12. The regnant fluid, which in the gaseous state is still considerably colder than the subject fluid, is then discharged in a continuous stream into the conduit 16, causing the colder, high oxygen content regnant fluid to commingle with the air circulated through the conduit 16. The air thus cooled and conditioned is exhausted into the space to be air conditioned through the discharge end 19 of the conduit.

A valve 21 is interposed in the conduit 12 to permit the flow of the vapor from the container 11 to be regulated. The valve 21 may be manually or thermostatically controlled to maintain the desired cabin temperature of, say, 70° to 80° F.

The system also includes provision for regulating the pressure of the upper vapor region of the container 11. To this end, a conduit 22 is provided. One end of the conduit 22 communicates with the upper vapor region of the container 11, and the other end of the conduit 22 communicates with a chamber 23 of a pressure controlled actuator. The actuator includes a housing 24 which contains a flexible diaphragm 25 in communication with the chamber 23. The opposite side of the diaphragm 25 is acted upon by a compressed spring 26.

The actuator regulates a valve 28 interposed in a return conduit 14 which connects the end of the vaporizing section or the beginning of the superheating section of the coils 15 with the conduit 22. The valve is mounted on a pivotal shaft 30, one end of which projects outboard of the conduit 14, and the diaphragm 25 is connected to the pivotal shaft 30 by a mechanical connection which includes a rod 27 connected to the diaphragm and an arm 29 which is fixed to the end of the pivotal shaft 30.

The conduit 14, in connecting the conduit 12 with the conduit 22, serves as a return passage for the regnant fluid in its vapor state at or slightly above its saturation temperature. The valve 28 interposed in the conduit 14 regulates the flow through this return passage. The actuator functions to regulate the valve 28 in such a manner as to regulate the pressure of the gas within the container 11. Since the pressure of the gas in the upper region of the container assists in feeding the liquid through the conduit, the rate of flow would tend to fall off if this pressure were not maintained. When this pressure is at or above the minimum level, the valve 28 is closed. However, when the pressure of the gas in the upper region of the container 11 falls below a predetermined value, the pressure decrease is transmitted through the conduit 22 to the chamber 23 of the actuator. The actuator then functions to open the valve 28, causing a return flow of the gas to the container through the conduits 14 and 22.

The invention has been shown in preferred form and by way of example only, and obviously many variations and modifications may be made therein without departing from the spirit of the invention. The invention, therefore, is not to be limited to any specified form or embodiment, except in so far as such limitations are set forth in the claims.

I claim:

1. An air conditioning system comprising a first passage communicating at both ends with the air to be conditioned, said first passage having an inlet end into which air to be conditioned is introduced and an outlet end from which conditioned air is discharged, a source of liquefied gas, and a second passage connecting the source of liquefied gas with the first passage, the said second passage including a portion thereof in heat exchange rela-

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tionship with the first passage in which the liquefied gas is vaporized, and a discharge opening for the second passage within the first passage and directed toward the outlet end thereof to discharge the vapor from the second passage into the first passage, thereby inducing a flow of air through the first passage.

2. An air conditioning system as set forth in claim 1 including a container for the liquefied gas, a return passage for part of the fluid in gaseous state flowing through the second passage, a control valve interposed in the return passage, and an actuator controlled by the pressure in the upper gaseous region of the container for regulating the control valve.

3. An air conditioning system comprising a first passage communicating at both ends with a space to be air conditioned, and a second passage having at one end an inlet in communication with a source of liquid air and at the other end an outlet in communication with the first passage, the said second passage including a portion thereof in heat exchange relationship with the first passage, permitting an exchange of heat from the fluid in the first passage to the liquid air in the second passage, which heat exchange cools the air flowing through the first passage and vaporizes and superheats the liquid air flowing through the second passage, the superheated fluid introduced through the outlet of the second passage into the first passage inducing a flow of air through the first passage between the inlet and discharge ends thereof.

4. An air conditioning system comprising a first passage communicating at both ends with a space to be air conditioned, the first passage including an inlet end into

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which warm air is introduced and a discharge end from which cooler air is exhausted, a container for liquefied air, a second passage which conducts the liquid air into heat exchange relationship with the air flowing through the first passage, the heat exchange between the air flowing through the first passage and the liquid air flowing through the second passage serving to cool the air flowing through the first passage and vaporize and superheat the liquid air flowing through the second passage, and an ejector within the first passage for discharging the superheated vapor into the first passage, thereby inducing a flow of air through the first passage between the inlet and discharge ends thereof and commingling with that air a fresh charge of cool gas of relatively high oxygen content.

5. An air conditioning system as set forth in claim 4 wherein the pressure in the upper region of the container for the liquefied air causes the flow of liquid air through the second conduit, and including pressure regulating means for the upper region of the container for the liquid air, said pressure regulating means including a return passage between the gaseous phase portion of the second passage and the container, a valve in said return passage, and means controlled by the pressure in the upper region of the container for opening the valve when the pressure in the upper region of the container falls below a predetermined level.

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