

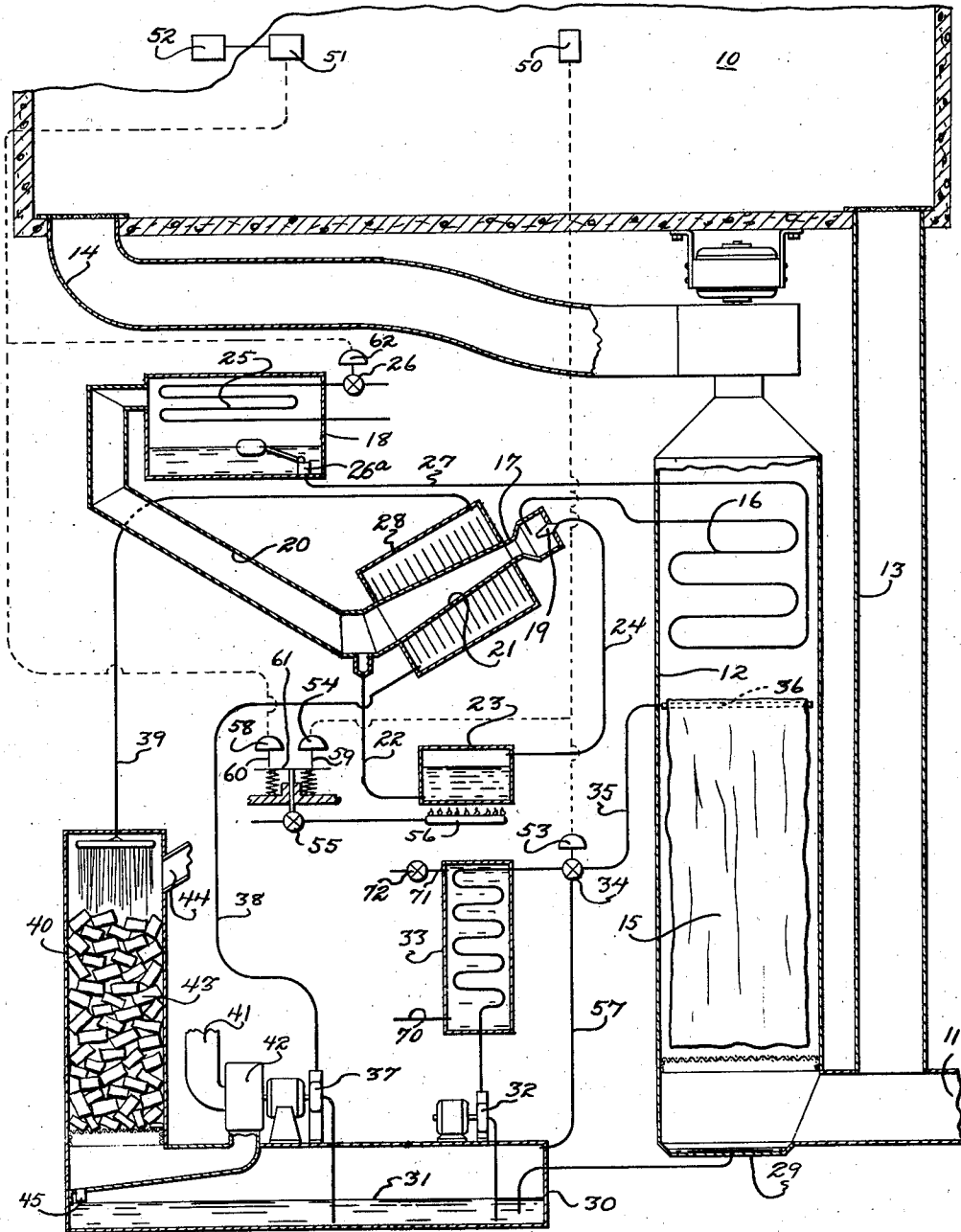
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REFRIGERATING APPARATUS

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REFRIGERATING APPARATUS

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This invention relates to a method and apparatus for conditioning a gas such as air in an improved manner.

It is among the objects of this invention to provide a method and apparatus for conditioning a gaseous medium, such as air, by means of an absorbent or hygroscopic medium and by thermal exchange with an expanding refrigerant. One of the features which may be embodied in the invention includes the utilization of the energy required in maintaining the refrigerating medium in proper condition to reactivate the absorbing medium. Another feature which may be embodied in the invention includes the correlation of the refrigerating and absorbing systems in such a manner that certain portions of one system cooperate with certain portions of the other system to enhance the total efficiency of the apparatus. The refrigerating and absorbing systems, however, may be so correlated that either system may operate, if necessary, entirely or partially, independently of the other system, so that either the refrigerating action or the absorbing action on the gas may be increased or decreased independently of each other as conditions of the gas require. This action may, if desired, be entirely or partially automatic.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing, wherein a preferred form of the present invention is clearly shown.

In the drawing:

The figure shows diagrammatically the embodiment now preferred for practicing my invention.

In practicing my invention, a gas is conditioned by subjecting the gas, such as air, to an absorbing and a refrigerating action. Thus, as an example, the air for an enclosure 10 is to be conditioned and maintained at desired temperature and/or relative humidity conditions by subjecting it to such actions. To this end, air from the outside may enter at 11 and may be conditioned in the casing 12. If desired, also, air from the enclosure 10 may be recirculated and reconditioned by causing it to pass through the passageway 13 to the intake or any other portion of the casing 12. Thus the air in the enclosure 10 is maintained in the desired condition by the introduction of properly conditioned air through the discharge passage 14, which air may be derived from the outside, or from the enclosure 10, or both. As is usual and if desired, when air from the outside is introduced into the enclosure

10, a substantially equal quantity of air is relieved from the enclosure 10 by any suitable means such as windows, ventilators or the like, not shown.

The casing 12 is provided with means 15 for 5 subjecting the air to an absorbing action by contacting it with an absorbent or circulating hygroscopic medium. The casing 12 is also provided with means for thermally exchanging heat between the air and an expanding refrigerant 10 preferably in the form of an evaporator 16. The absorbing or hygroscopic medium circulated through the contact apparatus 15 may be any suitable medium. I prefer, at present, to use an aqueous solution of the lithium halide-like 15 salts, such as lithium chloride, lithium bromide, lithium iodide, or any of the other lithium salts which have water vapor absorbing characteristics similar to said salts.

The refrigerant evaporated or expanded in 20 cooling the air, is compressed in a compressor 17, is condensed in a condenser 18 and is returned to the evaporator 16 where it is reexpanded for circulation again in the cycle. In the form now preferred, the refrigerant used is water or a 25 similar liquid, and the compressor 17 is preferably of the jet compressor type. It is of such construction that a vapor, such as mercury vapor, enters through the jet 19, compresses the water vapor, which water vapor is forwarded through 30 the pipe 20 to the condenser 18. The mercury, or other volatile medium, vapor is condensed in a condenser 21 and returns in the form of a liquid through pipe 22 to the boiler 23 where it is again turned into vapor and returned 35 through the pipe 24 to the jet 19 for circulation in a closed cycle. The water vapor in the condenser 18 is condensed by heat exchange with any cooling medium, such as water passing through the pipe 25. The flow of water is controlled by a valve 26 preferably automatically in accordance with conditions of the gas or air in the enclosure 10 in a manner hereafter to be more fully described. The flow of condensed refrigerant water is controlled by a float controlled 40 valve 26a which permits flow of water through the pipe 27 to the evaporator 16 as fast as the refrigerant water is condensed, thus maintaining only a sufficient and constant quantity of liquid in the condenser 18. The valve 26a 45 may act as an expansion valve for maintaining a pressure differential between the refrigerant water in the condenser 18 and in the evaporator 16.

The absorbing or hygroscopic liquid is reactivated

vated to maintain it in proper condition or concentration. Preferably this is accomplished by utilizing energy from the compression of the refrigerant or water in compressor 17. To this end, a heat interchanger 28 is provided in which the circulating hygroscopic liquid is heated by energy normally also used during compression of the refrigerant, such as by the latent heat of condensation of the mercury vapor which is being condensed in the condenser 21. The heat in the hygroscopic liquid thus obtained is utilized in the reactivation of the hygroscopic liquid as will more fully hereinafter appear.

In the preferred form of absorbing system or process, the circulating hygroscopic liquid is gathered in a sump 29, from the contact apparatus 15, and flows into a tank 30 in which the main body 31 of hygroscopic liquid is maintained in proper condition in a manner hereinafter described. One stream of hygroscopic liquid is circulated by means of an electrically driven pump 32 through a cooler 33 past two-way valve 34 and through a pipe 35 to a distributor 36 of the contact apparatus 15 where the liquid contacts with the air. Another stream of hygroscopic liquid, which is to be reactivated, is circulated by the electrically driven pump 37 through the pipe 38 to the heat exchanger 28 from whence the heated liquid flows through the pipe 39 to the concentrator 40. Here the liquid is concentrated by bringing it, in its heated condition, in contact with a stream of air which enters at 41 to the electrically driven blower 42 and passes upwardly through contact medium 43 of the concentrator 40 and is discharged, laden with water vapor, through the passage 44. The concentrated hygroscopic liquid returns, through the pipe 45, into the main body 31. The hygroscopic liquid is thus maintained in the proper concentrated condition in the body 31.

The construction and arrangement is such that the compressor 17 maintains proper refrigerating capacity and proper absorbing capacity and can vary these capacities independently of each other as conditions in the gas or air may require. To this end, the arrangement is such that the mercury vapor in the compressor 17 can be used either primarily for compressing water vapor and thus for supplying refrigeration at the evaporator 16, or it may be used primarily for heating the absorbent material passing through the exchanger 28, or it may utilize its compressing and/or heating capacities in varying and independent ratios as conditions may require.

The foregoing independent variation in the action of the refrigerating and absorbing systems may be automatic in its nature. Thus a humidostat 50 may be placed in the enclosure 10 which is calibrated to maintain any desired or constant relative humidity in the enclosure. Also, a dry bulb thermostat 51 may be placed in the enclosure which is calibrated to maintain any desired dry bulb temperature in the enclosure. This thermostat may, though not necessarily, maintain any desired temperature differential between the enclosure 10 and the dry bulb temperature outside of the enclosure, this latter differential being maintained by means of a connected dry bulb 52 placed outside of the enclosure as is well understood. The humidostat 50 is connected to control the motor or expansible bellows chamber 53 which operates the two-way valve 34 and is also connected to control the motor or expansible bellows chamber 54 which

operates the valve 55 which governs the flow of gas to the burner 56 for heating the mercury in boiler 23. The construction is such that when the relative humidity drops, thus requiring less absorption of vapor from the air, the valve 34 is turned to by-pass all or an increasing portion of the hygroscopic liquid through the pipe 57 back to the main body 31. This either reduces or completely stops the flow of hygroscopic liquid to the contact apparatus 15 and thus reduces or changes the absorbing action of the liquid on the air in accordance with conditions of the air in the enclosure 10. The converse action occurs when the relative humidity increases in the enclosure 10.

The valve 55 is subjected to a dual control from the chamber 54 and from the chamber 58 the control of which is to be hereinafter described. The construction is such that a downward movement of the rod 59 tends to open the valve 55 and a downward movement of the rod 60 also tends to open the valve 55. However, if only one of the rods 59 or 60 are moved upwardly away from the plate or lever 61, the valve does not close. It closes more or less only if both rods 59 or 60 permit such closure. Either rod 59 or 60 is free to move upwardly away from the plate 61 without varying the valve 55 while its lower end is above the lower end of the other rod. Thus the valve 55 is open to the maximum degree required by either of the expansible chambers 54 or 58, whichever is greatest.

The automatic variation of the refrigerating capacity independently of the absorbing capacity is accomplished by connecting the dry bulb thermostat 51 with a motor or expansible bellows chamber 62 which controls the flow of water through the pipe 25 by means of the valve 26, and thus controls the condensing action in condenser 18 and by connecting the thermostat 51 to the motor or expansible bellows chamber 58 which controls the valve 55 jointly with the motor 54 in the manner heretofore described. The connection between the thermostat 51 and the valves 26 and 55 is such that when the dry bulb temperature in the enclosure 10 falls, thus requiring less refrigeration, the valve 26 closes partially or completely and this reduces or stops the evaporating or cooling action of the evaporator 16 and thus reduces the refrigeration upon the air passing to the enclosure 10. Simultaneously with the closing of the valve 26, the chamber 58 tends to close the valve 55 and this tends to reduce the heating action on the mercury in boiler 23 and consequently tends to reduce the energy delivered to compressor 17 if the absorption system likewise does not require so much energy at 17. It is understood, as above described, that the operation of the valve 55 is dependent on the maximum requirement of either of the refrigerating or absorption systems.

The cooling action on the hygroscopic liquid in cooler 33 may be accomplished in any suitable manner and preferably is constructed to feed hygroscopic liquid to the contact apparatus 15 at a desired substantially constant temperature. Thus cooling water may enter through the pipe 70 and leave through the pipe 71, and a thermostatically responsive valve 72 may be provided, which automatically maintains a constant discharge temperature for the water leaving through the pipe 71. This in turn insures a substantially constant temperature of the medium delivered through the pipe 35 because of the constant heat exchange differential in cooler 33.

From the foregoing it will be seen, that the air passing through the casing 12 may be dried and cooled automatically in response to any requirements. If conditions require that the relative humidity should be decreased, so that the drying action should be increased, the humidostat 50 tends to open the valve 55 and tends to increase the flow of liquid through the pipe 35 into the distributor 36, thus increasing the drying action. Conversely, if the drying action should be decreased, the humidostat 50 tends to close the valve 55 and tends to decrease the flow through the pipe 35 by permitting or increasing the flow through the by-pass 57. The control on the refrigerating action is entirely independent of the control of the absorbing action. Thus if the temperature at 10 is too high, the thermostat 51 tends to open the valve 26 and the valve 55 thus increasing the refrigerating capacity of the evaporator 16. If the temperature in the enclosure 10 is too low, then the thermostat 51 tends to close the valve 26 and the valve 55 thus decreasing the refrigerating capacity of the evaporator 16.

An advantageous embodiment of my invention is one in which the compressing fluid, which circulates through the jet 19, has a relatively high condensing temperature with respect to the temperature required by the hygroscopic liquid at its point of contact with the air or gas. Thus where the fluid discharged through the jet 19 is mercury vapor, and where the hygroscopic liquid passing through the exchanger 28 is a lithium chloride solution, a very efficient action is obtained. For example, the condensing temperature of the mercury at 21 can be maintained at from 200° F. to 212° F. while still maintaining an efficient operation of the refrigerating system. At this temperature, the lithium chloride solution can be sufficiently concentrated to a degree such that, when it is contacted with the air at from 80° F. to 90° F., a very satisfactory relative humidity can be imparted to the air passing to the enclosure 10. In this embodiment, the entire dehumidifying load can be placed on the absorbing system, and substantially all of the refrigerating load, or at least the final cooling load, can be placed on the refrigerating system. This permits the evaporator 16 to be operated at a relatively high temperature, since it does not have to dehumidify the air. Such operation enhances greatly the conditioning capacity of the apparatus.

While I have described this invention as particularly applicable to the conditioning of air, it is to be understood that, in its broader aspects it is applicable wherever a gas is to be subjected during all or part of the time to a reaction, whether physical or chemical or both, with an affinitive medium which reacts with all or a part of the gas. Also, this invention may be embodied in other forms of devices than jet jump 19 and burner 56 for transforming potential energy into kinetic energy with the evolution of heat for reactivating the affinitive medium. Various means of transformation of the energy of a fuel into other forms of energy such as kinetic and heat energy may be used to produce the refrigerating effects and the reactivation of the affinitive medium. Thus while the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. The method of conditioning a gas which

comprises contacting said gas with an absorbing medium and then exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant and absorbing medium to maintain proper conditions in said gas.

2. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and directly exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant to maintain proper conditions in said gas.

3. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and directly exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said absorbing medium to maintain proper conditions in said gas.

4. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and exchanging heat between said gas and an expanding refrigerant, operating a compressor, utilizing said compressor to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said compressor independently on said refrigerant and absorbing medium to maintain proper conditions in said gas.

5. An apparatus comprising a contactor for contacting a gas with an absorbing medium and exchanging heat with an expanding refrigerant, a jet compressor for said refrigerant, a volatile compressing medium for said jet compressor, a condenser for said compressing medium, means using heat from said condenser for reactivating said absorbing medium, means for changing the refrigerating capacity of said refrigerant in accordance with conditions in said gas, means for automatically changing the absorbing action of said absorbing medium on said gas in accordance with conditions in said gas, the construction and arrangement being such that said jet compressor maintains said refrigerant and said absorbing medium in proper condition independently of the demands upon said refrigerant or absorbing medium.

6. The method of conditioning air which comprises contacting said air with a liquid circulating hygroscopic medium and exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of mercury vapor which is condensed, and utilizing the heat of condensation of said mercury vapor to reactivate said hygroscopic medium out of contact with said air.

7. The method of conditioning air which comprises contacting said air with a liquid circulating hygroscopic medium and then exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of a volatile compressing agent which is condensed, and utilizing the heat of condensation of said agent to reactivate said hygroscopic medium, out of contact with said air.

8. The method of conditioning air which comprises contacting said air with a liquid circulating hygroscopic medium and then exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded, with the aid of a compressing agent and with the release of heat from said agent, and utilizing said heat to reactivate said hygroscopic medium out of contact with said air.
9. The method of conditioning air which comprises contacting said air with a hygroscopic medium and exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of mercury vapor which is condensed, and utilizing the heat of condensation of said mercury vapor to reactivate said hygroscopic medium.
10. The method of conditioning air which comprises contacting said air with a hygroscopic medium and then exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of a volatile compressing agent which is condensed, and utilizing the heat of condensation of said agent to reactivate said hygroscopic medium.
11. The method of conditioning air which comprises contacting said air with a hygroscopic medium and then exchanging heat between said air and an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of a compressing agent and with the release of heat from said agent, and utilizing said heat to reactivate said hygroscopic medium.
12. The method of conditioning a gas which comprises contacting said gas with an affinitive medium and directly exchanging heat between said gas and an expanding refrigerant, reliquefying said refrigerant thus expanded by the aid of a power cycle with the evolution of waste heat from said power cycle and utilizing said heat to reactivate said affinitive medium.
13. The method of conditioning a gas medium which comprises contacting said gas medium with an affinitive medium, exchanging heat between one of said mediums and an expanding refrigerant, compressing the refrigerant thus expanded by the aid of a thermal power cycle with the evolution of waste heat from said power cycle, utilizing said heat to reactivate said medium, and increasing the amount of heat thus utilized as the demand for reactivation increases in response to a change in humidity.
14. In combination, a conditioner for a room, a source of energy for operating said conditioner, mechanism controlling the energy output, and means controlling said mechanism in accordance with room humidity and temperature differential between the room and the outside.
15. The method of conditioning gas which comprises contacting said gas with a first medium for altering the humidity content of the gas, passing said gas in indirect heat exchange with a second medium for controlling the temperature of the gas, reactivating said first medium and compressing said second medium in a common device and varying the action of said device on said mediums so as to maintain proper conditions in said gas.
16. In air conditioning apparatus, a contactor for contacting a gas with an absorbing medium and means for causing heat exchange between said gas and an expanding refrigerant, and means responsive to humidity conditions of said gas controlling the reactivation of said medium and the compression of said refrigerant.
17. In air conditioning apparatus, a refrigerant, an absorbing medium, mechanism for compressing said refrigerant and reactivating said absorbing medium, a thermostatic device, a humidistatic device and means selectively responsive to the combined action of said devices or the individual action of either of said devices for regulating said mechanism, means responsive to humidity controlling the absorbing action of said medium, and means responsive to temperature for controlling the cooling action of said refrigerant.
18. In an air conditioning system, a refrigerant, a hygroscopic liquid, a source of heat, means utilizing said heat for compressing said refrigerant and for reactivating said hygroscopic liquid, means for subjecting air to be conditioned to the influence of the refrigerant and the hygroscopic liquid, and means controlling the amount of heat supplied in response to temperature and humidity conditions.
19. In air conditioning apparatus, means for contacting a gas with an absorbing medium, refrigerating means for cooling said gas, means whereby waste heat from said refrigerating means is used for reactivating said medium, and humidity responsive means for regulating the contacting of the gas with the absorbing medium and for regulating the reactivation of the absorbing medium.
20. The method of conditioning a gas which comprises flowing said gas into contact with an absorbing medium and into thermal exchange with an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant and absorbing medium to maintain proper conditions in said gas.
21. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant and absorbing medium automatically in response to a psychrometric condition of the gas so as to maintain proper conditions in said gas.
22. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and then exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant automatically in response to changes in a function of the psychrometric condition of said gas so as to maintain proper conditions in said gas.
23. The method of conditioning a gas which comprises contacting said gas with an absorbing medium and exchanging heat between said gas and an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said absorbing medium automatically in response to changes in a function of the psychrometric condition of said gas so as to maintain proper conditions in said gas.

24. The method of conditioning a gas which comprises flowing said gas into contact with an absorbing medium and into thermal exchange with an expanding refrigerant, vaporizing, expanding and condensing a volatile compressing agent, utilizing said agent to recompress said refrigerant and to reactivate said absorbing medium, and varying the action of said agent on said refrigerant to maintain proper conditions in said gas.

25. The method of conditioning air which comprises flowing said air into contact with a hygroscopic medium and thereafter flowing said air into thermal exchange relationship with an expanding refrigerant, recompressing the refrigerant thus expanded with the aid of a compress-

ing agent and with the release of heat from said agent, utilizing said heat to reactivate said hygroscopic medium, and increasing the amount of heat available for reactivating said hygroscopic medium in response to an increase in humidity.

26. An apparatus for conditioning air or the like comprising air flow means, means for contacting air at said air flow means with an affinitive medium, a refrigerating system including a refrigerant liquefying unit and a refrigerant evaporator in heat exchange relationship with air in said air flow means, and means utilizing waste heat from said liquefying unit for reactivating said affinitive medium.

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