ABSTRACT

An absorption refrigeration system using a two or more substance solution to achieve refrigeration that eliminates the need for a pump. The vapor pressure in a generator column is balanced by a pressure head of liquid solvent-solute solution. Re-dissolved solute is returned to the generator by causing some of the vapor to pass through a perforated tube or the like into the solvent where it is absorbed. At least some of the vapor is cooled to liquid solute and then expanded through an expansion valve into an evaporator to create a refrigerator. Hot vapor from the generator column can be passed through a jet to create a low pressure in the evaporator. No pump is necessary since the liquid is returned to the heating area of the generator by gravity. Closed loop control of the heating can optionally be achieved by using a pressure sensor in the rising generator column.

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PUMPLESS ABSORPTION REFRIGERATOR USING A JET

[0001] This application is related to and claims priority from U.S. Provisional patent application Ser. No. 60/902,132 filed Feb. 20, 2007. Application 60/902,132 is hereby incorporated by reference.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates generally to the field of absorption refrigerators and more particularly to an absorption refrigerator that eliminates the need for a pump.

[0004] 2. Description of the Prior Art

[0005] A typical prior art absorption refrigeration system utilizes a solution of two substances having different boiling points. Turning to FIG. 1, a schematic of a typical prior art system can be seen. A first container acts as a generator or still where the liquid with the lower boiling point (the solute) is distilled from the liquid with the higher boiling point (the solvent) by the application of heat. The vapor of the solute thus produced passes to a condenser or condensing container where the vapor liquefies on cooling by exchanging heat with the external atmosphere or a liquid shower like a water shower. The cooled liquid is then permitted to vaporate through a restricted passageway into an evaporator having lower pressure. This process is endothermic and hence results in refrigeration. The relatively low pressure of the evaporator container is due to absorption of the lower boiling point vapor or gas by higher boiling point solvent when the vapor passes into an absorber container. The “rich” liquid produced in the absorber is then sent back to the generator for another cycle usually by a pump. Liquid from the generator container which has become “weak” due to the removal of the solute is cooled and admitted to the absorber where it can absorb more solute vapor or gas causing reduced pressure in the absorber. In many cases, additional heat exchangers and purifiers are added to improve efficiency. A very common practice is to use ammonia as the solute and water as the solvent liquid. Like any binary solution, the boiling point varies with the relative concentrations of the two substances becoming higher as more ammonia leaves the solution. By putting solute back into the solvent, the entire system can be operated in equilibrium at a fairly constant temperature and pressure in the generator.

[0006] While the prior art refrigeration system described can perform quite well in a number of circumstances, it requires a pump to return “rich” fluid from the absorber to the generator. This is because in the prior art system, the liquid needs to be transferred against a pressure gradient from the low pressure absorber to the high pressure generator. Where electricity is plentiful, this may not be a problem; however, for remote locations or portable use, it would be advantageous to have an absorption refrigeration system that does not need a pump.

SUMMARY OF THE INVENTION

[0007] The present invention relates to an absorption refrigeration system using a two-substance or binary solution to achieve refrigeration that successfully eliminates the need for a pump. This is a great advantage for use in a location where there is little or no electricity, since about half of the world’s population lives without electricity. The system still needs heat; however, this can be delivered by bottled gas, steam, or any other source of heat including burning wood or other substances. Providing heat is a relatively easy problem in the art, pumping a volatile liquid against a pressure gradient is a relatively difficult problem, especially without electricity.

[0008] The present invention replaces the pump by using a head of liquid to balance vapor pressure in a generator and a nozzle to help create a low pressure in and evaporator. The energy the pump would supply is supplied by gravity and by heat.

DESCRIPTION OF THE FIGURES

[0009] Attention is now directed to several figures to help understand the present invention:

[0010] FIG. 1 shows a schematic diagram of a prior art system.

[0011] FIG. 2 shows a piping view of an embodiment of the present invention. Several drawings and illustrations have been provided to aid in understanding the present invention. The scope of the present invention is not limited to what is shown in the figures.

DESCRIPTION OF THE INVENTION

[0012] The present invention relates to a liquid solvent absorption refrigerator that functions with no pump. An embodiment of the present invention is shown in FIG. 2 in the form of a piping diagram. It should be noted that various solutions of different substances can be used in the present invention. The most common and preferred solution is ammonia in water, so for further example in this description, ammonia and water will generally be used. Any solution of two or more substances with different boiling points is within the scope of the present invention.

[0013] Ammonia is distilled from water as previously described in a generator vessel 1 by the application of heat from a heat source 12. The vapor so generated pressurizes the vessel 1, and the riser column 2. Pressure is maintained at a predetermined value by a pressure sensor 3 that transmits a signal to the heat source 12 forming a control loop known in the art. It is possible to construct the present invention without a pressure sensor, since if the pressure gets too high, the liquid will pull away from the heating area. However, it is preferred to use a sensor 3 to avoid fuel waste. A thermostatically operated valve 4 allows or disallows gaseous ammonia to pass from the riser column 2 to an ejector 5 depending on the temperature of the exit vapor from an evaporator 6 to be discussed. A check valve 7 prevents return of vapor to the evaporator when there is no flow through the ejector 5. When the thermostatically operated valve 4 is open, hot ammonia gas passes from the column 2 to the jet nozzle of the ejector 5 and through the venturi or narrower part of the ejector 5 to the condenser 9 and/or perforated tube 10 located in an absorber section 14. Heat exchange with the surroundings lowers the temperature of the ammonia in the condenser 9 liquefying it. Extended tubing in the absorber section 14 may be needed to
remove heat from the ammonia gas since absorption generates some heat that needs to be removed by exchange with the ambient. The liquid ammonia gravitates to an expansion valve or orifice 8. The action of the ejector 5 creates a low pressure in the evaporator 6 along with the lower pressure also created by the absorption process so that when the liquid ammonia passes through the expansion valve, it evaporates with an accompanying drop in temperature. The rest of the ammonia gas that enters the perforated tube 10 contacts the solvent in the vertical section of the generator 14 and is there absorbed by the ammonia-water solution in the generator tube.

[0014] As stated, ammonia flow through the ejector 5 produces a low pressure in the evaporator 6 in accordance with the Bernoulli principle. Cooled ammonia liquid passes through the expansion valve 8 where it expands changing to a gaseous state. This free expansion takes place at almost constant enthalpy and is well-known in the art of refrigeration to be endothermic. Hence the coils in the evaporator 6 cause the evaporator space 13 to become cold. The enclosed and insulated evaporator space 13 becomes a refrigerator. It should be noted that additional ejectors possibly combined with coolers could be arranged in series with the ejector 5 to provide lower pressure in the evaporator 6 if desired or needed. The expanded ammonia vapor then reenters the condenser 9 and absorber 14 through the check valve 7 previously described.

[0015] Rich ammonia-water fluid is returned to the generator by the pressure head 1 caused by the vertical nature of the piping. There is a balance of pressure of the liquid in the descending part of the generator (pressure caused by the head H) against the pressure created by the vapor in the rising part of the generator 1. As previously stated, this can be controlled by the pressure sensor 3 at the top of the rising generator 1 which adjusts the heat input to the generator from the heat source 12. As previously stated, the pressure sensor 3 is optional. It is not possible to overpressurize the generator because as pressure increases beyond a particular amount, the liquid is pushed away from the heat source.

[0016] In some embodiments of the present invention, depending on the substances used and the vertical size, the pressure head H can be made sufficient so that 100% refrigerant such as ammonia can be used. In this embodiment, the absorber with solute 14, 10 is not necessary and can be removed by disconnected at points A, B and C in FIG. 2 and installing a connection at the point marked D.

[0017] The over-all continuous operation is then that a solution is vaporized in a generator from a solution (or pure substance) by the application of heat. The pressure in the generator is balanced against a pressure head of liquid in a descending section of the generator. The exact amount of heat to maintain the pressure balance can be controlled by a pressure sensor that feeds back a signal to the heat source or can be simply allowed to operate at a pressure equilibrium. The hot vapor is jetted and condensed in a condenser and then expanded through an expansion valve into an evaporator to produce refrigeration in a closed, generally insulated, refrigerator space. Additional jetted vapor can be taken off and re-dissolved in the solvent in an absorber using a device like a perforated tube in the descending part of the generator. The jet causes a low pressure in an evaporator along with the pressure drop caused by the absorption process. The pressure head of the liquid column depends on the height of the column from the base of the generator to the level of the solvent (where the perforated tube or other device that allows the vapor to dissolve in the solvent).

[0018] It should be noted that most of the solvents stays liquid constantly maintaining the required pressure head. As is well-known in the art, whenever an binary solution is heated, the first vapor that leaves is almost 100% pure solute. Without continuous refreshment of solute into the solvent, the boiling point of the remaining solution gradually increases, and the vapor begins to contain more and more solvent. This is the case in the distillation of spirits. However, in the case of the present invention, the mixture is continuously refreshed with solute that is re-dissolving in the solvent (at the perforated tube 10 in FIG. 2). For this reason, the vapor produced in the rising generator column 2 remains almost pure, and the boiling temperature remains constant.

[0019] While ammonia-water solutions have been used in examples, many other binary and other solutions can be used with the present invention. The selection of solutions is governed mainly by the pressure needed to condense at atmospheric temperatures and the heat transfer characteristics, boiling points and toxicity of the liquids. Ammonia-water is preferred as one of the best possible solutions. It's disadvantage is toxicity. Water in lithium bromide can be used (and is non-toxic). Here, water is the solute and refrigerant. However, water boils at high temperatures compared to ammonia. This can lead to much higher operating temperatures and pressures. This can be overcome by maintaining very low pressures in the system (on the order of about 2 inches of mercury absolute in the condenser). This allows the system to operate at much lower temperatures. Other possible solutions are alcohol-water, chlorine-water, HCl-water, and many others. Any solution of two or more liquids, gasses or gas-liquids of different boiling points is within the scope of the present invention. Material used for piping must be chosen based on the substances used in the mixture. For example, ammonia reacts with copper and hence copper piping cannot be used with ammonia. Other substances may react with other types of piping.

[0020] Several descriptions and illustrations have been presented to aid in understanding the present invention. One skilled in the art will realize that numerous changes and variations are possible without departing from the spirit of the invention. Each of these changes and variations is within the scope of the present invention.

1 claim:
1. An absorption refrigerator not requiring a pump comprising:
   a generator column with a rising portion and a descending portion, said rising portion being heated and containing vapor; said descending portion containing liquid, said liquid forming a pressure head in said descending portion, wherein said pressure head balances pressure of said vapor in said rising portion;
   a jet attached to said rising portion of said generator column, wherein said vapor is jetted through said jet creating a low pressure in an evaporator, and wherein said vapor cools and liquefies to form said liquid in said descending portion
   wherein at least some of said liquid is passed through an expansion device into said evaporator creating a refrigerator
2. The absorption refrigerator of claim 1 wherein said liquid is a solution of a solute in a solvent.
3. The absorption refrigerator of claim 1 wherein said vapor is ammonia.
4. The absorption refrigerator of claim 2 wherein said solvent is water.
5. The absorption refrigerator of claim 2 wherein said solute is ammonia.
6. The absorption refrigerator of claim 2 further comprising an absorption section where said solute re-dissolves in said solvent.
7. The absorption refrigerator of claim 6 wherein said absorption section includes a perforated tube.
8. The absorption refrigerator of claim 1 further comprising a closed-loop control of pressure in said rising portion using a pressure sensor in said rising section controlling a heat source.
9. An absorption refrigerator requiring no pump that uses a solution of a solute and a solvent, said solute having a boiling point lower than that of said solvent comprising:
   a generator with a heated vapor-containing portion and a liquid-containing portion, said liquid-containing portion forming a pressure head that balances pressure in said vapor-controlling portion;
   a condenser in proximity to said generator;
   an absorber in proximity to said condenser;
   an evaporator in proximity to said condenser;
   an ejector jet coupling said generator to said condenser,
   wherein vapor in said generator is jetted into said condenser causing a decrease in pressure in said evaporator,
   and wherein a portion of said vapor enters said absorber and is re-dissolved in said solvent, said absorber being connected to said liquid-containing portion of said generator;
   and wherein another portion of said vapor condenses in said condenser forming a liquid that is passed through an expansion device into said evaporator causing a drop in temperature in said evaporator, and wherein expanded gas passes from said evaporator into said condenser.
10. The absorption refrigerator of claim 9 further comprising a check valve between said evaporator and said condenser that prevents vapor from said condenser from entering said evaporator.
11. The absorption refrigerator of claim 9 further comprising a pressure sensor in said vapor-containing part of said generator.
12. The absorption refrigerator of claim 11 wherein said pressure sensor controls a heater heating said generator.
13. The absorption refrigerator of claim 9 wherein said absorber contains a perforated tube.
14. The absorption refrigerator of claim 9 wherein said solute is ammonia.
15. The absorption refrigerator of claim 9 wherein said solvent is water.
16. A method of absorption refrigeration comprising the steps of:
   heating a solute-solvent solution causing said solute to boil off vapor into a rising portion of a generator column;
   jetting said vapor through a jet into a condenser, said jet causing a drop in pressure in an evaporator;
   condensing said solute to a liquid in said condenser;
   expanding said liquid solute through an expansion device into said evaporator;
   allowing expanded solute vapor to re-enter said condenser;
   causing a portion of said vapor in said condenser to enter an absorber where it re-dissolves in a column of liquid solute-solvent solution, said column of solution in a descending portion of said generator column, and wherein said column of liquid forms a pressure head that balances pressure of said vapor in said rising portion of said generator column.
17. The method of claim 16 wherein said solute is ammonia.
18. The method of claim 16 wherein said solvent is water.
19. The method of claim 16 further comprising the step of controlling heating of said generator using a pressure sensor in said rising portion of said generator.
20. The method of claim 16 further comprising using a check valve between said evaporator and said condenser to prevent solute vapor from entering said evaporator from said condenser.

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