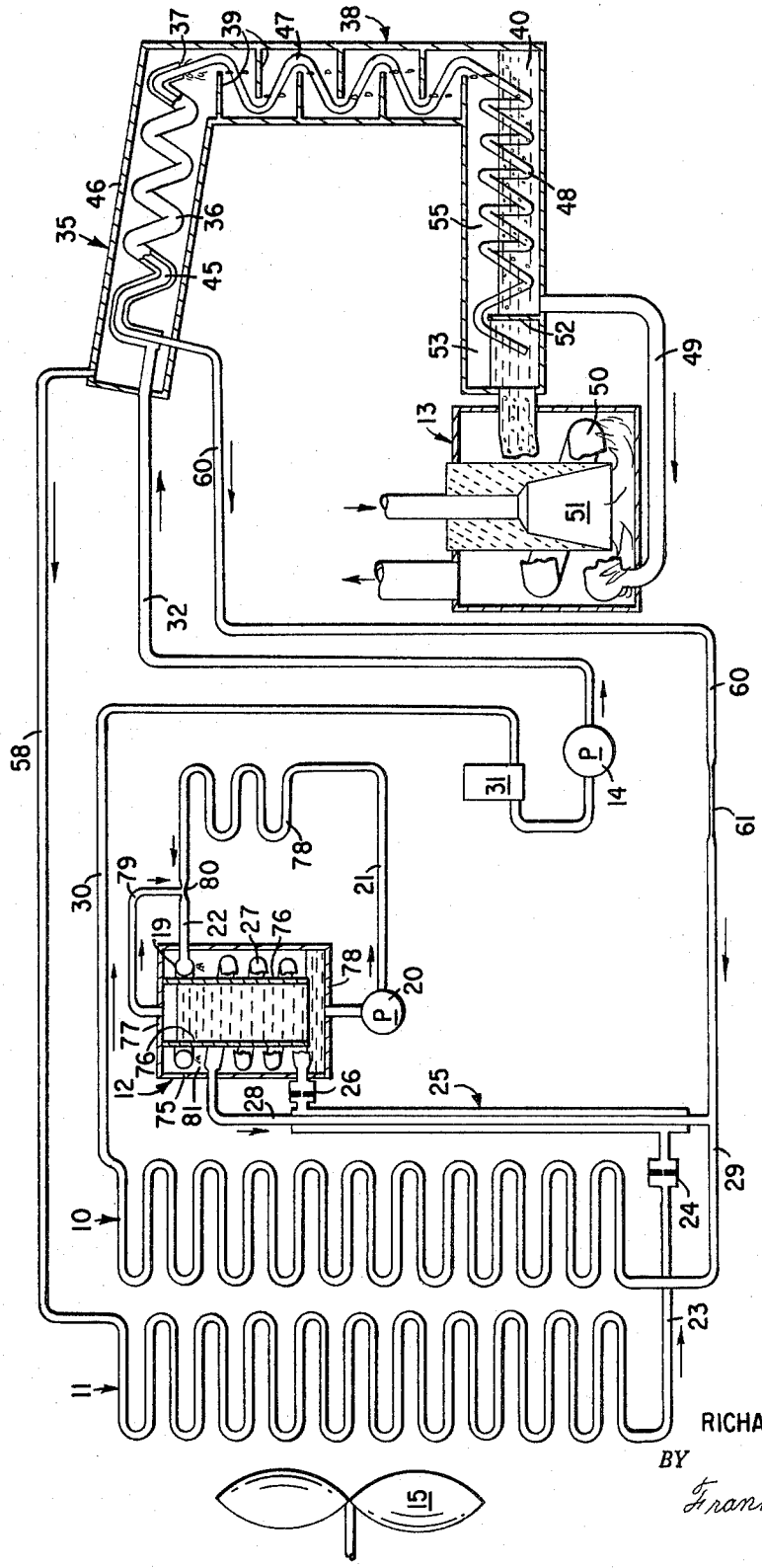
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REFRIGERANT EVAPORATION

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REFRIGERANT EVAPORATION

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This invention relates to refrigerant evaporation and, more particularly, to absorption refrigeration systems of the type employing an evaporator to chill a liquid heat exchange medium which is passed to a remote location to provide cooling.

Absorption refrigeration systems of the type with which this invention may be used generally include an evaporator section having an evaporator coil in which refrigerant is vaporized. A liquid heat exchange medium, such as water, is distributed over the evaporator coil and is chilled by heat exchange with the evaporating refrigerant. The chilled water is pumped to a heat exchanger in a remote location for cooling a refrigeration load and the water is returned from the remote location back to the fluid distribution means for rechilling in the evaporator.

While it is obviously desirable to keep the heat exchange liquid distribution circuit of such a system as liquid-tight as possible it often happens that over a period of extended use some of the heat exchange medium may be lost. Loss of the heat exchange medium may occur because of installation, replacement, or repair of existing or new heat exchangers in the region being cooled, or more often may result from minute leakage of liquid from the seal of the pump which is generally used to pass the heat exchange medium through the distribution circuit.

Loss of the heat exchange medium eventually results in unsatisfactory performance of the refrigeration system and requires the liquid distribution circuit be refilled, resulting in periodic maintenance. If the quantity of heat exchange medium in the liquid distribution circuit becomes too greatly diminished, lack of medium may result in malfunction of the pump due to cavitation or if the pump is provided with a safety device, it will render the refrigeration machine inoperative until a sufficient quantity of heat exchange medium has been provided at the suction of the pump.

Since it is desirable to keep the size of the refrigeration system as small as possible, it would be convenient to store excessive make-up water for the liquid distribution circuit in the evaporator vessel. However, with evaporators of the type herein described, flooding of the evaporator coil by the make-up water is undesirable because it impairs heat transfer and the storage of excessive make-up water in the evaporator would require the evaporator to chill an unnecessarily large quantity of water.

It is a principal object of this invention to provide an improved absorption refrigeration system and method of operating the same.

It is a further object of this invention to provide an improved evaporator construction and method of operating the evaporator of an absorption refrigeration system.

It is a further object of this invention to provide an evaporator construction for storing make-up water which does not interfere with the normal cooling of the chilled water being distributed over the evaporator coil.

The objects of this invention are achieved in the illustrated embodiment thereof wherein an absorption refrigeration system is provided with an evaporator having an inner shell member forming a water storage region and an outer shell member which is disposed about, and spaced from, the inner shell member to form an evaporator region. The evaporator coil of the absorption refrigeration system is disposed in the evaporator region between the inner and outer shell. A heat exchange liquid distribution circuit, including a pump and an external heat exchanger, is provided to pass water chilled by the evaporator coil through the external heat exchanger and back to a fluid distribution header for redistribution and rechilling thereof. An eductor is disposed in series with the heat exchange liquid distribution circuit so that water is pumped through the eductor. The eductor is provided with a low pressure throat region which is connected by a fluid passage to the upper portion of the water storage chamber.

When the refrigeration system is not in operation, the pump is inoperative and water partially fills both the water storage region and the evaporator region. When the refrigeration system is placed in operation, the pump also becomes operative and water is pumped through the eductor. Since the low pressure throat region of the eductor is in communication with the upper portion of the water storage region, water is drawn out of the evaporator region and into the water storage region where it remains out of the normal path of circulation of the liquid distribution circuit. The withdrawal of water from the evaporator region uncovers the evaporator coil so that the water being circulated can be distributed over the external surfaces of the evaporator coil by the liquid distributor for efficient heat transfer. This system automatically establishes a level of water in the evaporator sufficient to assure adequate liquid head on the suction of the pump to prevent cavitation. In the event of leakage of some water from the liquid distribution circuit less water will be drawn by the eductor into the liquid storage region thereby providing the required make-up water.

Other features and objects of this invention will become more readily apparent by referring to the following specification and attached drawing wherein the figure is a schematic flow diagram of an absorption refrigeration system embodying this invention.

Referring particularly to the drawing, there is shown an absorption refrigeration system having an absorber 10, a condenser 11, an evaporator 12, and a generator 13 connected to provide refrigeration. A pump 14 is employed to circulate weak absorbent solution from absorber 10 to generator 13. As used herein, the term "weak absorbent solution" refers to a solution which is weak in absorbing power, and the term "strong absorbent solution" refers to a solution which is strong in absorbing power. A suitable absorbent solution for use in the system described is water, and a suitable refrigerant is ammonia. For convenience, the absorbent liquid will be referred to as an "absorbent solution" although it will be appreciated that pure water is not technically a solution.

A chilled water pump 20 is provided for forwarding water, or other heat exchange medium chilled in evaporator 12, through chilled water line 21 to heat exchanger 78 in a suitable remote location for chilling a refrigeration load. The water is then returned from heat exchanger 78 through chilled water line 22 to a spray header 19 from which it is again distributed over the exterior of evaporator coil 27.

In accordance with this invention, evaporator 12 comprises an outer cylindrical shell 75 having a top member 77 and a bottom member 78 secured to shell 75 to form a liquid-tight closed evaporator vessel. An inner cylindrical shell 76 is disposed within outer shell 75 in spaced relation thereto. The space between shells 75 and 76 form an evaporator region 81 in which evaporator coil 27 and liquid distributor 19 are located.

Inner shell 76 is hollow and forms in its interior a liquid storage chamber 82 for storing the heat exchange liquid. Inner shell 76 is spaced from bottom 78 of the closed evaporator vessel so that the lower region of liquid storage chamber 82 is in fluid communication with evaporator

region 81 as shown in the drawing. The upper region of shell 76 is made substantially liquid-tight so that it is not in direct communication with evaporator region 81. As shown in the drawing, the upper portion of inner shell 76 may be brazed or otherwise secured to top 77 of shell 75 to seal it from evaporator region 81.

It will be appreciated that the construction of evaporator 12 described herein is illustrative of a preferred embodiment thereof, but evaporator 12 may take a wide variety of configurations within the scope of this invention. The important feature of evaporator 12 is that regardless of its physical arrangement, it has an evaporator region and a storage vessel having a portion in fluid communication with the evaporator region and another portion sealed from the evaporator region.

It will be seen that a heat exchange liquid distribution circuit comprising pump 20, external heat exchanger 78, eductor 80, liquid distributor 19 and the evaporator vessel 12 is provided for distributing chilled water to the desired remote location and returning it back to the evaporator for rechilling. A fluid passage 79 connects the low pressure throat region of eductor 80 to the upper region of the heat exchange liquid storage chamber.

In operation, pump 20 withdraws water chilled by passage over evaporator coil 27 from evaporator 12 and passes it to heat exchanger 8 through leaving chilled water line 21 where it is employed to cool a refrigeration load. The water returns from heat exchanger 78 through entering chilled water line 22 and eductor 80, which is in series therewith, to liquid distributor 19 disposed above evaporator coil 27 in evaporator region 81.

Before the refrigeration system is put in operation, the level of water or other heat exchange medium in exchanger 12 will be equalized between inner storage chamber 82 and evaporator region 81. Thus, a substantial volume of water can be stored in the evaporator vessel. When the refrigeration system is put in operation and pump 20 is started, the flow of water through eductor 80 will induce vapor from the upper region of storage chamber 82 through line 79 into entering line 22 and liquid distributor 19. Consequently, the pressure in the upper region of storage chamber 82 will be lower than that in evaporator region 81 and water will be induced from the evaporator region into the storage chamber, thus uncovering heat exchange coil 27. The level of water remaining in evaporator region 81 will be determined by the point at which storage chamber 82 is in communication with the evaporator region. In the embodiment illustrated in the drawing, the level of water will be substantially the same as the distance between the bottom of inner shell 76 and bottom 78 of shell 75. Since evaporator coil 27 is not flooded in operation, effective heat transfer will take place between the water passing over the exterior surface of the evaporator coil from liquid distributor 19. The water, cooled by heat exchange with the evaporating refrigerant inside evaporator coil 27, drops to the bottom of evaporator 12 and is passed by pump 20 to external heat exchanger 78.

It will be apparent that by making the volume of storage chamber 82 sufficiently large, there can be accommodated within evaporator 12 sufficient water to make up any losses which might occur over a desired period of time in the liquid distribution circuit. The construction described automatically establishes a predetermined liquid level in evaporator 12 sufficient to prevent cavitation or other damage to pump 20. Consequently, if water is lost from the liquid distribution circuit, the level to which water will rise in the storage chamber will be diminished but there always will be sufficient water in the liquid distribution circuit for effective operation of the refrigeration system.

Liquid refrigerant is passed from condenser 11 through liquid line 23, refrigerant restriction 24, the exterior passage of liquid suction heat exchanger 25 and second refrigerant restriction 26, to evaporator coil 27 of evaporator 12. Heat from the water to be chilled, passing over the exterior of evaporator coil 27, is given up to the refrigerant which vaporizes in the interior passage of the evaporator coil. The refrigerant vapor passes from coil 27 through vapor line 28, the interior passage of liquid suction heat exchanger 25, to mixing line 29 where it is mixed with strong solution returning to the absorber from the generator.

The mixture of refrigerant vapor and strong solution passes through mixing line 29 into the heat exchange coil which forms absorber 10. Air is passed over the exterior of the absorber coil by fan 15 to cool absorbent solution therein and increase its absorbing power. The absorbent solution is weakened as it absorbs refrigerant vapor during its passage through the absorber. By the time the absorbent solution reaches the discharge end of the absorber coil, the refrigerant vapor is completely absorbed in the absorbent solution and the solution has become weak in absorbing power by the absorption of the vapor.

The weak absorbent solution passes through weak solution line 30 to a purge tank 31 where noncondensible gases are collected and withdrawn from the system. The weak solution is then forwarded by solution pump 14 through weak solution line 32 to combine rectifier and heat exchanger section 35.

Rectifier and heat exchanger section 35 comprises an outer shell 46 forming a vapor passage. Shell 46 contains an inner heat exchange coil 45 and a concentric outer heat exchange coil 36, as shown in the drawing. Preferably outer heat exchange coil 36 is spirally disposed along the inner wall of shell 46 and it may be provided with suitable fins for enhancing heat transfer.

Coils 36 and 45 form a solution heat exchanger between the entire quantity of relatively hot strong solution passing from the generator to the absorber and the entire quantity of relatively cool weak solution passing from the absorber to the generator. The amount of heat transfer surface provided between the strong and weak solution is designed so that the weak solution is brought to just about its boiling point so that vapor is not formed in the solution heat exchanger.

The weak solution from line 32 passes through coil 36 in the annular space between inner heat exchange coil 45 and outer heat exchange coil 36 where the weak solution is heated to substantially its boiling point by heat exchange with strong solution. After passing through coil 36, the heated weak solution is discharged from opening 37 onto one of a plurality of baffles or plates 39 in analyzer column 38.

Analyzer 38 comprises a tubular member having a plurality of plates 39 which provide surfaces for contact of vapor with the reflux and the solution which wets the surfaces of the plates. The weak solution passes successively over the plurality of plates and is discharged from the bottom of the analyzer into a generator reservoir 40. Generator reservoir 40 provides solution storage for part load operation conditions and allows for solution and refrigerant charging tolerance, and compensates for manufacturing variations in machine volume.

Weak solution from generator reservoir 40 passes through line 49 into generator coil 50. The solution in coil 50 is heated by suitable means such as gas burner 51 causing the solution to boil thereby forming vapor. The vapor and hot solution is discharged from coil 50 into separation chamber 53, formed by a baffle or weir 52, where the vapor separates from the remaining strong solution. Preferably, some of the solution normally spills over the top of baffle 52 and is recirculated through line 49 to generator coil 50. It will be understood that the solution in separation chamber 53 has been concentrated by vaporizing refrigerant therefrom in generator 13.

Vapor formed in generator 13 passes concurrently with strong solution through the vapor passage 55 formed in the upper portion of generator reservoir 40, through

analyzer **38**, and through the vapor passage formed by shell **46** of rectifier **35** to condenser **11**.

The concentrated or strong absorbent solution from separation region **53** is at the relatively high generator pressure and passes through heat exchange coil **48** in generator reservoir **40**, heat exchange coil **47** in the analyzer column, and inner heat exchange coil **45** in the rectifier. The strong solution then passes through line **60** and restriction **61** into mixing line **29** and absorber **10** on the relatively low pressure side of the system.

Heat from the strong solution passing through coil **48** boils the weak solution in the generator reservoir to vaporize refrigerant therefrom. The heat exchange which takes place in the generator reservoir results in cooling the strong solution flowing through coil **48** so that it enters the analyzer and rectifier respectively at the best temperature to achieve maximum efficiency with minimum heat transfer surface.

A portion of coil **48** is submerged below the level of weak solution in reservoir **40** and another portion of the coil is disposed in the vapor passage above the weak solution. The boiling of the weak solution causes the portion of coil **48** which is disposed in vapor passage **55** to be wetted with solution. As the strong solution passes through coil **48**, it becomes progressively cooler. Vapor formed in the generator and in the reservoir passes through the vapor passage **55** and contacts the exposed and wetted portion of coil **48** in reservoir **40**, and mass and heat transfer takes place with the weak solution boiling in the reservoir. It will be appreciated that ammonia vapor will be boiled from the weak solution in the reservoir and that water vapor will be condensed from the vapor space into the weak solution in proportions resulting in an enrichment of the refrigerant content of the vapor passing through the reservoir. Also the condensation of water vapor into the weak solution will liberate additional heat which assists in vaporizing the solution.

Similarly, as the vapor passes from the reservoir upwardly through analyzer column **38**, a mass and heat transfer takes place between the weak solution passing downwardly over plates **39** in the column and further enriches the refrigerant content of the vapor.

The vapor then passes through rectifier **35** where it is placed in heat exchange relation with the weak solution passing through coil **36**. The heat transfer which takes place in the rectifier results in condensing additional water from the vapor which then leaves the rectifier in a highly purified or enriched state.

The purified refrigerant vapor passes from rectifier **35** through line **58** into the coil of condenser **11**. Fan **15** passes air over condenser **11** causing the refrigerant vapor to condense. The condensed refrigerant passes through line **23** and restriction **24** into evaporator **12**, as previously explained.

As the vapor passes through rectifier **35**, the reflux or solution which is condensed, flows by gravity to analyzer **38** and passes downwardly through the analyzer column along with weak solution discharged from outlet **37** of coil **36**. This rectifier condensate is heated along with weak solution in the analyzer to produce additional vapor by heat exchange with strong solution passing through coil **47**.

It will be seen that by the use of this invention, the internal volume of the evaporator vessel is utilized to provide storage space for water to make up for that which may be lost from the liquid distribution circuit. In this arrangement, any loss of water in the liquid distribution circuit is automatically replenished from the stored water in the evaporator. At the same time, the stored water does not flood the evaporator coil during periods of operation, nor does it circulate in the circuit. The stored water is effectively withdrawn from the circuit during operation and is not required to be chilled by the evaporator. Also, the proper liquid head on the suction of the pump in the liquid distribution circuit is automatically maintained so that cavitation of the pump is prevented. The system is relatively compact and inexpensive to manufacture and by replenishing lost water it improves and increases the service-free life of the machine.

While preferred embodiments of this invention have been described for purposes of illustration, it will be appreciated that this invention may otherwise be embodied within the scope of the following claims.

I claim:

1. An evaporator construction for use in a refrigeration system for cooling a liquid heat exchange medium by placing said medium in heat exchange relation with evaporating refrigerant, said evaporator comprising:
   - (A) shell means defining an evaporating region adapted to contain a quantity of liquid heat exchange medium;
   - (B) shell means defining a storage vessel adapted to contain a quantity of liquid heat exchange medium, said storage vessel being in fluid communication with said evaporator region;
   - (C) an evaporator heat exchanger disposed in said evaporator region to effect heat exchange between evaporating refrigerant and heat exchange medium in said region;
   - (D) a liquid pump for circulating said heat exchange medium from said evaporator region through a heat exchange liquid distribution circuit, and returning said heat exchange medium to said evaporator region;
   - (E) means providing a low pressure throat region disposed in said heat exchange liquid distribution circuit; and
   - (F) vapor passage means connecting said low pressure throat region with a vapor space in said storage vessel for reducing the pressure in said storage vessel, thereby withdrawing excess heat exchange medium from said evaporator region into said storage vessel when said heat exchange medium is circulated through said heat exchange liquid distribution circuit.

2. An absorption refrigeration system comprising:
   - (A) an absorber for absorbing refrigerant vapor;
   - (B) a generator for concentrating weak absorbent solution by vaporizing refrigerant therefrom;
   - (C) a condenser for condensing refrigerant vaporized in said generator; and
   - (D) an evaporator for evaporating refrigerant to produce cooling, said evaporator comprising:
     - (1) an outer shell,
     - (2) an inner shell disposed within said outer shell and spaced therefrom, said inner shell also forming an inner storage chamber,
     - (3) a top member sealingly engaging the top of said inner shell,
     - (4) an evaporator coil disposed in the space between said inner and outer shells,
     - (5) a pump for circulating a heat exchange liquid to be chilled through a heat exchange liquid circuit and for discharging said fluid over said evaporator coil,
     - (6) an eductor having a low pressure throat disposed in said heat exchange liquid distribution circuit; and
     - (7) passage means connecting the throat of said eductor with said inner chamber formed by said inner shell and said top member.

3. An absorption refrigeration system comprising:
   - (A) an absorber for absorbing refrigerant vapor;
   - (B) a generator for concentrating weak absorbent solution by vaporizing refrigerant therefrom;
   - (C) a condenser for condensing refrigerant vaporized in said generator; and
   - (D) an evaporator for evaporating refrigerant to produce cooling, said evaporator comprising:
     - (1) an outer shell,

(2) an inner shell disposed within said outer shell and spaced therefrom to form an evaporator region between said shells, said inner shell forming an inner storage chamber in its interior, said inner storage chamber being sealed from said evaporator region at its upper portion and being open to said evaporator region at its lower portion,

(3) an evaporator coil disposed in said evaporator region between said inner and outer shells,

(4) a pump for circulating a heat exchange fluid to be chilled through a fluid passage and discharging said fluid over said evaporator coil for chilling said fluid,

(5) an eductor having a low pressure throat disposed in said fluid passage, and

(6) passage means connecting the throat of said eductor with the upper portion of said inner storage chamber.

4. An absorption refrigeration system comprising:

(A) an absorber for absorbing refrigerant vapor;

(B) a generator for concentrating weak absorbent solution by vaporizing refrigerant thereform;

(C) a condenser for condensing refrigerant vaporized in said generator; and

(D) an evaporator for evaporating refrigerant to produce cooling, said evaporator comprising:

(1) an inner shell forming a liquid storage chamber, said storage chamber being substantially closed at its upper portion,

(2) an outer shell member spaced from said inner shell and forming an evaporator region therebetween, said evaporator region being in communication with the lower region of said liquid storage chamber,

(3) an evaporator coil disposed in said evaporator region between said inner and outer shells,

(4) a heat exchange liquid distribution circuit comprising means to distribute heat exchange liquid to be cooled over said evaporator coil, means including a passage for passing chilled heat exchange liquid to a remote location to provide cooling, and a passage for returning the heat exchange liquid from the remote location for redistribution over said evaporator coil,

(5) a pump to circulate said heat exchange liquid through said distribution circuit,

(6) an eductor having a low pressure throat disposed in said heat exchange liquid distribution circuit,

(7) passage means connecting said low pressure throat to the upper region of said liquid storage chamber.

5. An absorption refrigeration system comprising:

(A) an absorber for absorbing refrigerant vapor;

(B) a generator for concentrating weak absorbent solution by vaporizing refrigerant therefrom;

(C) a condenser for condensing refrigerant vaporized in said generator; and

(D) an evaporator for evaporating refrigerant to produce cooling, said evaporator comprising:

(1) a hollow outer cylindrical shell member having a bottom member and a top member secured in liquid-tight engagement with said shell member to form a closed evaporator vessel;

(2) a hollow inner cylindrical shell member disposed within said outer shell member in spaced relation with the shell and bottom of said outer shell member and defining an evaporator region between said shells, said inner cylindrical shell defining a liquid storage chamber in its interior, said liquid storage chamber being substantially closed at its top and open to said evaporator region at its bottom,

(3) an evaporator coil disposed in said evaporator region;

(4) a liquid distributor disposed in said evaporator region above said evaporator coil for distributing a heat exchange liquid to be chilled over said evaporator coil;

(5) leaving liquid passage means for passing heat exchange liquid, chilled by heat exchange with refrigerant evaporating in said evaporator coil, to a heat exchanger in a desired location for cooling said location;

(6) entering liquid passage means for passing said heat exchange liquid from said heat exchanger in said desired location back to said liquid distributor for redistribution of said liquid over said evaporator coil and rechilling of said liquid;

(7) a pump connected to pump said heat exchange liquid through said leaving passage means, said heat exchanger, and said entering passage means;

(8) an eductor having a low pressure throat region disposed in series with said entering liquid passage means; and

(9) passage means connecting said low pressure throat region of said eductor to said liquid storage chamber adjacent the upper portion thereof, so that when heat exchange liquid passes through said eductor, liquid in said evaporator region will be withdrawn from said evaporator region into said liquid storage chamber to uncover said evaporator coil while establishing a predetermined desired level of heat exchange liquid in the bottom of said closed vessel to provide a sufficient head on the suction of said pump to prevent cavitation thereof.

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