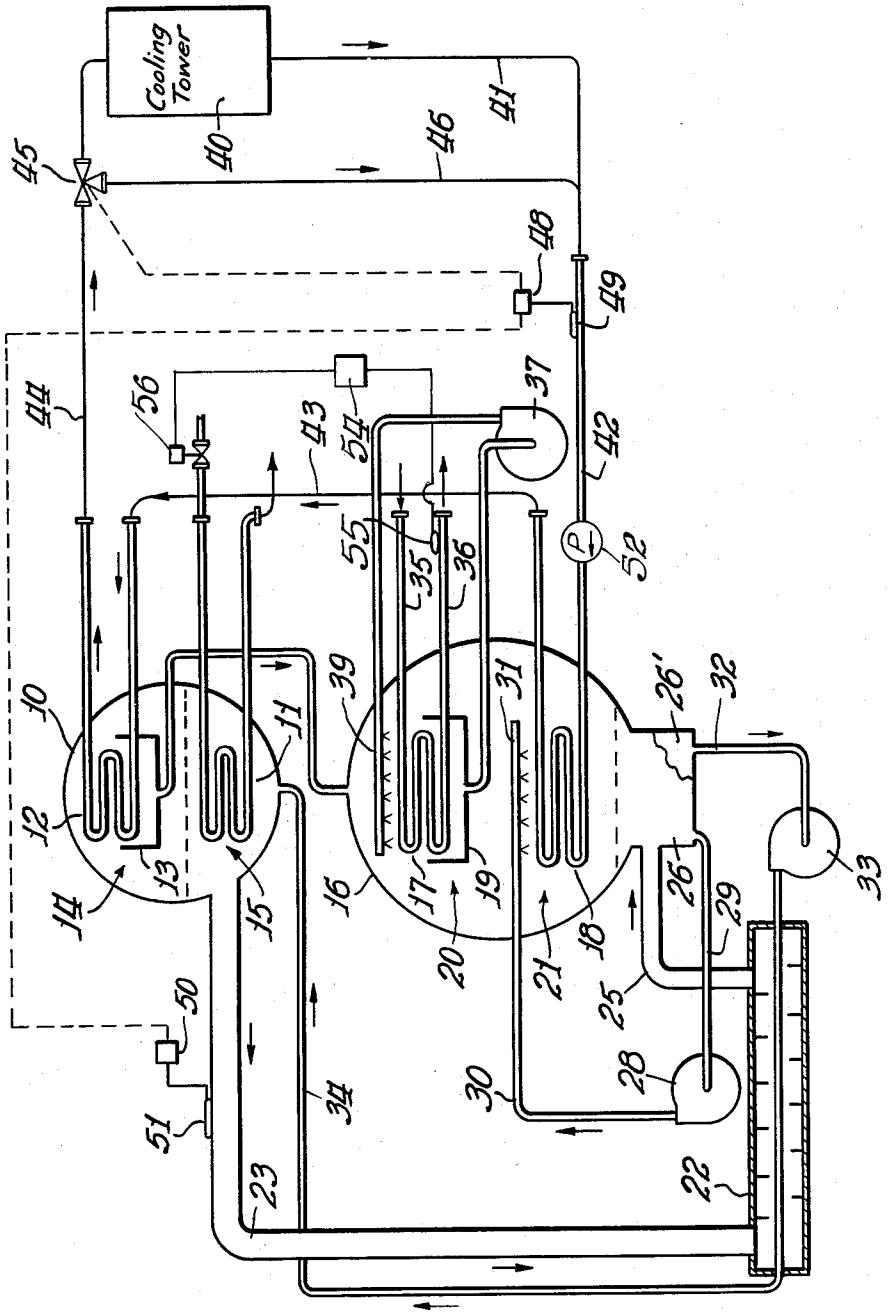
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ABSORPTION REFRIGERATION APPARATUS AND METHOD

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Inventor:
Neil E. Hopkins

By: Thomas B. Hunter
Atty.

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ABSORPTION REFRIGERATION APPARATUS AND METHOD

Neil E. Hopkins, Spring Garden Township, York County, Pa., assignor to Borg-Warner Corporation, Chicago, Ill., a corporation of Illinois

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This invention relates to an improved control system for continuous cycle, absorption refrigeration apparatus, and more particularly to a method and apparatus for minimizing contamination of the refrigerant due to explosive flashing and violent boiling in the generator. In a conventional absorption refrigeration system, for example the type which utilizes a hygroscopic brine as the absorbent, as low load operation, or at system startup, the solution throughout the system is more dilute than it is during full load operation. Since the increase in water content in the solution lowers the boiling point of the solution, the generator becomes more vulnerable from the standpoint of possible violent boiling action. This condition would be most aggravated at a condition of low salt concentration, such as exists at low load, or system startup, if there is a fairly sudden demand in increased capacity such that the steam valve goes to a fairly wide open position. The violence of the action at this condition can be much greater than that which exists at full 100% plant capacity, at which conditions the concentration of solution both entering and leaving the generator are considerably higher. Various devices, such as eliminators and baffles, are used to prevent solution carryover from the generator to the condenser. It is relatively easy to apply such devices to prevent slopover of this nature during full load operation. However, under the conditions discussed above, boiling action can be so violent that eliminators and baffles are unable to completely prevent slopover. This condition can cause the solution to be carried with the refrigerant into the condenser and the resulting contamination of the refrigerant by the lithium bromide solution reduces the refrigeration capacity.

The present invention takes preventative action when low concentrations prevail by raising the condensing water temperature supplied to the absorption system. This raises the condensing water temperature to the condenser in the top shell, and thus raises the condensing temperature and pressure. This increased pressure reduces the violence of boiling, such that even with low concentrations and a condition which causes the steam valve to open wide on a sudden demand for additional cooling, solution carry-over is virtually eliminated.

At full load, the condensing water temperature is returned to its initial design point. Thus this invention brings about a change in condensing water temperature control to the absorption system, varying from a design condensing water temperature at 100% design load, to a somewhat higher condensing water temperature at a lower load.

In order to achieve this control in a practical manner, the control system must take advantage of certain relationships between solution concentration and temperature. For example, the temperature of solution leaving the generator is related to the concentration of solution leaving the generator, and also in a general way it is related to the concentration of the solution entering the generator. By using temperature responsive controls instead of means to sense the solution concentration, it is possible to simplify the control system and incorporate it into a conventional absorption system at reasonable cost.

In brief, the absorption refrigeration system of the present invention varies the condensing water temperature to the absorption system as the load varies. For a given

load, the cooling water temperature is maintained at a fixed condition by a submaster control with a temperature sensitive bulb in the cooling water line for the absorber and condenser. As the system capacity varies, corresponding to a change in the solution concentration and consequently a change in the temperature from the generator, the control temperature of the submaster instrument is reset. This action is gradual because of the flywheel effect of the solution concentration change, and consequently, a slow rate of change takes place in solution temperature.

At the maximum load it is necessary that the condensing water temperature be at the minimum design setting (usually 85° F.) in order to obtain full equipment capacity. At low load, corresponding to a reduction in concentration throughout the system, it is desired to raise the condensing temperature in the top shell to reduce boiling potential on a later demand for increased cooling.

In summation then, the control system utilizes a first temperature control means for maintaining the cooling water in the circuit at the proper temperature. This control means, in a preferred embodiment, is operative to selectively divert the cooling water through a cooling tower or through a conduit which bypasses the cooling tower. In addition to this temperature control, which is more or less conventional in absorption systems, the present invention also includes a second (master) temperature controller which is responsive to the temperature of the solution leaving the generator to vary the control point of the first temperature controller, which for the purpose of this invention is a type capable of resetting (submaster).

It is therefore a principal object of the present invention to provide an improved control system for an absorption refrigeration apparatus in order to reduce the boiling activity within the generator and avoid contamination of refrigerant in the condenser.

Additional objects and advantages will be apparent from a reading of the following detailed description taken in conjunction with the drawing wherein:

The figure is a diagrammatic representation of an absorption refrigeration system embodying the principles of the present invention.

For the purpose of this specification, it will be assumed that the absorption refrigeration system described herein is of the type which employs a hygroscopic brine as the absorbent and water as the refrigerant. Inasmuch as lithium bromide solution has been found to be a suitable absorbing medium, reference will sometimes be made to a system employing this salt as the absorbent, but it should be understood that the invention has general application to absorption refrigeration systems using any of several other known absorbent-refrigerants. Also for purposes of illustration, the "concentrated" solution means a solution of relatively higher concentration in lithium bromide (approximately 64.5 percent at maximum capacity), while the "dilute" solution may be defined as a solution relatively lower in concentration of lithium bromide (approximately 59.5 percent at maximum capacity).

Turning now to the figure, a first shell **10** is provided having a heat-exchanger **11** and a heat-exchanger **12** disposed therein. A pan or receptacle **13** positioned below heat-exchanger **12** combines therewith to form a condenser **14**, and heat-exchanger **11** cooperates with the shell **10** to form a generator **15**.

A second shell **16**, ordinarily positioned below shell **10**, includes a pair of heat-exchangers **17** and **18**. Heat-exchanger **17** is provided with a pan **19** which cooperates therewith to form an evaporator **20** and heat-exchanger **18** cooperates with the lower portion of shell **16** to provide an absorber **21**. A pressure differential exists between shells **10** and **16** corresponding to the condenser

pressure and evaporator pressure of the refrigerant (water).

The absorber has a pump **28** associated therewith for continuously circulating solution from sump **26** through conduits **29** and **30** to a spray header **31** located above heat-exchanger **18**. The concentrated solution from the generator mixes with the more dilute solution in sump **26** to form an intermediate strength solution. Alternatively, the concentrated solution supply line **25** may be connected directly to line **29**. In any case, the capacity of the absorber pump **28** is greatly in excess of the flow of concentrated solution from the generator so that all of the concentrated solution from the generator plus considerable quantity of dilute solution from the absorber is supplied to spray header **31**.

A hot concentrated solution line **23** leads from the lower portion of generator-condenser shell **10** to the heat-exchanger **22**. In order to increase the efficiency of the system, it has been found to be desirable to provide a heat-exchanger **22** to transfer heat from the hot solution leaving the generator to the relatively cool dilute solution from the absorber. A concentrated solution line **25** leads from the heat-exchanger **22** to a dilute solution sump **26** (shown partially broken away to illustrate a separate sump **26'**) provided in the lower portion of shell **16**.

A dilute solution line **32** connects the generator pump **33** to a second sump **26'**, referred to above, which is spaced longitudinally of the shell **16** from sump **26** and entirely separate therefrom. The cool dilute solution from the absorber is then passed through heat-exchanger **22**, in heat-exchange relation with the hot concentrated solution, and supplied to the generator through line **34**.

In the evaporator, water or some other suitable exchange medium is supplied to heat-exchanger **17**, commonly referred to as the chilled water coil, through line **35** from the individual room units and returned to said units through line **36**. The evaporator has a refrigerant pump **37** associated therewith, said pump being arranged to continuously circulate liquid refrigerant collecting in pan **19** to a spray header **39** above heat-exchanger **17**. Under normal operation conditions, the chilled water from the room units, e.g., induction of fan coil units, enters the chilled water coil **17** at approximately 54° F. and leaves through line **36** at approximately 44° F.

Cooling water for the absorber and the condenser is supplied from a cooling tower **40** of any conventional design, and is pumped by pump **52** through lines **41** and **42** to the heat-exchanger **18** disposed in the absorber section for removing heat generated by dilution of the concentrated absorber solution, and then through line **43** to heat-exchanger **12** disposed in the condenser section. Heat-exchanger **12** is connected by means of line **44** to a three-way valve **45** which is adapted to selectively divert water either through cooling tower **40** or a bypass line **46** arranged in parallel therewith. If the minimum cooling water temperature is called for, all of the water is diverted through the cooling tower, and if some higher cooling water temperature is desired, a portion or all of the water leaving the condenser heat-exchanger **12** through line **44** may be diverted to the bypass line **46** which is connected into line **42** downstream from the cooling tower.

An important aspect of the present invention concerns the control system for adjusting the cooling water temperature in response to varying conditions, and particularly at system start-up and under the low load conditions when the concentration of the absorber solution is relatively dilute. As mentioned above, if there is a fairly sudden demand for increased capacity such that steam or hot water valve **56** (controlled in response to the load and commonly operated, for example, by a control unit **54** and a bulb **55** sensing the leaving chilled water temperature in line **36**) moves to a wide open position, the control system of the present invention takes remedial action to prevent violent boiling in the generator. A submaster temperature responsive controller **48** having bulb **49** is arranged to sense the temperature of water flow in line **42** before it is directed into the absorber heat-exchanger **18**. A master controller **50** having bulb **51** responsive to the temperature of the concentrated solution leaving the generator through line **23** is adapted to adjust the control point at which the submaster controller is set. For example, at start-up or low load, the solution concentration may be in the neighborhood of 54 percent lithium bromide leaving the absorber and 58 perecnt leaving the generator and the corresponding temperature of the solution leaving the generator, sensed by the master controller, would be approximately 150° F. A proper setting for the condenser water temperature would be 92° F. At high load, the solution concentrations would be approximately 59.5 percent leaving the absorber and 64.5 percent leaving the generator. The solution temperature at the master controller would be approximately 210° F. The submaster temperature would be reset for 85° F. Since the temperature of the cooling water entering the absorber heat-exchanger bears a direct relationship with the temperature of the water entering the condensing coil, it is possible to locate the temperature bulb at any place in the system past the juncture of the bypass line **46** with the line **41** leading from the cooling tower.

With reference to the temperature controllers, many devices capable of carrying out the control requirements are available on the market. However, for the purpose of completing this disclosure, controllers **48** and **50** may be of the types designated as model T–901 and T–900, both manufactured by the Johnson Service Company, Milwaukee, Wisconsin.

While this invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of this invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

What is claimed is:

1. An absorption refrigeration system comprising an evaporator, an absorber, a generator, and a condenser connected to provide a closed refrigeration circuit; means for conducting relatively dilute solution from said absorber to said generator; means for conducting relatively concentrated solution from said generator to said absorber; a conduit for supplying a heating medium to the generator in heat exchange with the solution therein; a capacity control valve placed in said conduit, said valve being operated in response to the cooling load; a cooling water circuit including a cooling tower, conduit means for circulating a relatively fixed quantity of water in a closed circuit from said cooling tower to said absorber and condenser in series; means for varying the temperature of the cooling water in said cooling water circuit, said means including first temperature control means responsive to the temperature of cooling water entering the absorber; second temperature control means responsive to the temperature of relatively concentrated solution conducted from said generator, said second control means acting as a master control to reset the control point of said first temperature control means such that said first temperature control means functions as a submaster control, whereby said first and second temperature control means are operative to raise the temperature of the cooling water supplied to the absorber and condenser as the temperature of solution from the generator drops.

2. An absorption refrigeration system comprising an evaporator, an absorber, a generator, and a condenser connected to provide a closed refrigeration circuit; means for conducting relatively dilute solution from said absorber to said generator; means for conducting relatively concentrated solution from said generator to said ab-

sorber; means for circulating water to be chilled to and from said evaporator; a conduit for supplying a heating medium to the generator in heat exchange with the solution therein; a capacity control valve placed in said conduit; first temperature control means for operating said capacity control valve in response to the temperature of chilled water leaving said evaporator; a cooling water circuit including a cooling tower, a pump and associated conduit means for circulating a relatively fixed quantity of water in a closed circuit from said cooling tower to said absorber and condenser in series flow, a by-pass conduit connected in parallel with said cooling tower and a second control valve operative to selectively control the flow of cooling water to the tower and to said by-pass conduit to vary the temperature of the cooling water in said cooling water circuit; a second temperature control means responsive to the temperature of cooling water entering the absorber to operate said second control valve; third temperature control means responsive to the temperature of said relatively concentrated solution conducted from said generator, said third control means acting as a master control to reset the control point of said second temperature control means such that said second temperature control means functions as a submaster control, whereby said second and third temperature control means are operative to raise the temperature of the cooling water supplied to the absorber and condenser as the solution temperature from the generator drops.

3. A method of operating an absorption refrigeration system of the type including an evaporator, an absorber, a generator, and a condenser connected to provide a closed refrigeration circuit; means for conducting relatively dilute solution from said absorber to said generator, means for conducting relatively concentrated solution from said generator to said absorber, comprising the steps of supplying a heating medium to the generator in heat exchange with the solution therein; varying the supply of said heating medium in response to the cooling load; circulating a relatively fixed quantity of cooling water in a closed circuit to said absorber and condenser in series flow; controlling the temperature of the cooling water in said cooling water circuit in response to the temperature of cooling water entering the absorber to maintain the temperature at some predetermined value; measuring the temperature of the relatively concentrated solution conducted from said generator to obtain an approximate indication of the concentration of said solution; and raising said predetermined temperature value of said cooling water as said solution temperature drops.

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ROBERT A. O'LEARY, *Primary Examiner.*

CHARLES R. REMKE, *Assistant Examiner.*