PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Refrigeration Systems

We, CARRIER ENGINEERING COMPANY LIMITED, a Company incorporated under the laws of Great Britain, of 24, Buckingham Gate, London, S.W.1, England, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to refrigeration systems. The chief object of the present invention is to provide an improved and economical continuous cycle absorption refrigeration system capable of more satisfactory performance and which may be manufactured at a cost considerably less than systems of such type heretofore contemplated.

A continuous cycle absorption refrigeration system according to the invention comprises in combination a shell, a member in said shell co-operating with the shell to form an absorber, a second member in the shell co-operating therewith to form an evaporator, said shell having means for maintaining a predetermined pressure therein, a second shell disposed adjacent the first shell, a member in said second shell co-operating therewith to form a generator, an element in said second shell co-operating therewith to form a condenser, said second shell having means for maintaining a predetermined pressure therein different from the pressure in said first shell, the shells being adapted to be sealed from one another in respect of flow of vapour, and means for circulating solution between the separate shells.

An absorption refrigeration system according to the invention is particularly adapted for use in air conditioning applications or in any application in which temperatures above the freezing temperature of water are desired. It will be understood however that the present invention may also be employed in low temperature refrigeration fields.

Broadly speaking, a refrigeration system according to the invention may have a pump for withdrawing weak solution from the absorber and forwarding it to the generator, and an ejector, said pump serving to pass a portion of weak solution into the ejector, the discharge of weak solution in the ejector serving to entrain strong solution from the generator to form a mixture of weak and strong solution and to supply the mixture to the absorber.

The term "weak solution" is used herein to define a solution containing a large amount of refrigerant so that the solution is weak in absorbing properties. The term "strong solution" defines a solution which is relatively deficient in refrigerant and consequently a solution which possesses enhanced properties of refrigerant absorption.

Various combinations of refrigerant and absorbent may be used. It has been found that a solution consisting of lithium bromide and water is highly satisfactory for use. Other salt solutions may be used if desired in the system; when the system is operated at high temperatures (above freezing temperature) a solution of lithium chloride and water or a solution of sodium hydroxide and water for example may be used. It will be understood when the present invention is used to attain low temperatures, ammonia, for example, may be used as a refrigerant.

A heat exchanger may be provided, which is adapted to place strong and weak solution in the said lines in heat exchange relation to one another.

Means may be provided for purging the condenser and the absorber of non-condensible gases, such means comprising a housing, a steam line connected to the housing, an ejector in said steam

line, a line connecting the ejector with the absorber whereby passage of steam at high velocity to said injector is adapted to entrain gases from said line, a cooling coil in said housing adapted to condense steam discharged into the housing, a second line connecting the condenser with the housing so that higher pressure in the condenser shell will force non-condensible gases into said housing, a water line, a second ejector disposed in said water line, and a line connecting said housing to said second ejector, passage of water at high velocity through said second ejector serving to entrain liquid and gases in said housing and discharge the same from the system.

In order that the invention may be more clearly understood reference will now be made to a preferred embodiment thereof, in a continuous cycle absorption refrigeration system constructed as illustrated in the accompanying diagrammatic drawings:—

Figure 1 is a diagrammatic view illustrating the flow of solution through the various elements of the refrigeration system;

Figure 2 is a view in side elevation of the absorption refrigeration device of the invention;

Figure 3 is a view in end elevation of the device shown in Figure 2;

Figure 4 is a sectional view through the shell including the absorber and the evaporator;

Figure 5 is a sectional view through the shell including the generator and the condenser;

Figure 6 is a view partly in section and partly in elevation illustrating a suitable spray arrangement for supplying refrigerant to the evaporator;

Figure 7 is a sectional view taken on the line 7—7 of Figure 6;

Figure 8 is a fragmentary sectional view drawn to enlarged scale to illustrate the position of the nozzles in the spray arrangement of Figure 6;

Figure 9 is a sectional view of the nozzle shown in Figure 8;

Figure 10 is a plan view of the nozzle shown in Figures 8 and 9;

Figure 11 is a sectional view of a modified spray arrangement;

Figure 12 is a sectional view taken on the line 12—12 of Figure 11;

Figure 13 is a plan view of the absorber spray arrangement;

Figure 14 is a view in side elevaton of the spray arrangement of Figure 13;

Figure 15 is a view in end elevation of the spray arrangement of Figure 13;

Figure 16 is a view in elevation of the heat exchanger;

Figure 17 is a sectional view on the line 17—17 of Figure 16;

Figure 18 is a sectional view longitudinally of the part of the heat exchanger shown in Figure 17;

Figure 19 is a view in elevation showing the manner in which the condenser tank is disposed in the shell;

Figure 20 is a sectional view on the line 20—20 of Figure 19;

Figure 21 is a sectional view on the line 21—21 of Figure 19;

Figure 22 is a view in elevation illustrating the manner in which the purge pipe is supported in the absorber; and

Figure 23 is a sectional view showing the means by which a secure joint is formed between the purge pipe and the absorber and header.

In the drawings like reference designate the same or similar parts.

Referring to the drawings, there is provided a framework including a base 2 and supports 3 secured to the base adapted to carry horizontally extending drums or shells 4 and 5. Shell 5 preferably is secured in place above shell 4. Shell 4 encloses a longitudinally extending absorber arrangement 6 and a longitudinally extending evaporator arrangement 7 disposed above the absorber 6.

Chilled water treated by the system is circulated by a pump 8 through an air conditioning device of any desired type (not shown) and is returned from the air conditioning device to the evaporator 7 through line 9. The chilled water is sprayed in evaporator 7 by a suitable spray arrangement 10, the chilled water being flash cooled in the evaporator and being drawn from the evaporator through line 11 by pump 8 and again forwarded to the air conditioning device.

Shell 5 encloses a longitudinally extending generator arrangement 12 and a longitudinally extending condenser arrangement 13 disposed above the generator 12. Weak solution is withdrawn from absorber 6 by pump 14 through line 15 and is forwarded to the generator 12 through lines 16, 17, heat exchanger 18 and line 19. Strong solution is withdrawn from generator 12 through line 20, overflow arrangement 21, line 22, heat exchanger 18 and line 23 to an ejector 24 which forwards strong solution through line 25 to the absorber 6. It will be noted line 23 is looped for a purpose hereinafter described. These solutions are disposed in heat exchange relation by means of heat exchanger 18 hereinafter described. Solution overflow arrangement 21 serves to prevent solution in the generator 12 rising above or sink-

ing below a predetermined level as hereinafter explained.

A pump 26 passes cooling water through line 27 to the coil of the absorber 6 and then forwards the water after its passage through absorber 6 through line 28 to the coil of condenser 13; in some cases, if desired, the direction of flow may be reversed, the cooling water being directed first to the coil of the condenser 13 and then to the coil of the absorber 6. After passage through the coil of condenser 13, the water is discharged or, if desired, may be reused, in which case a cooling tower is used. While cooling water has been described as passing in series through the coils of the absorber and condenser, it will be understood cooling water may be passed in parallel through such coils. If desired, of course, any suitable means may be provided to supply water for cooling purposes.

A line 29 is adapted to withdraw vapour condensate from condenser 13, the vapour condensate passing through a precooler assembly 30 and then being returned through line 31 to the evaporator 7. The condensate precooler 30 consists of a double pipe assembly in which a cooling medium is passed in heat exchange relation with the vapour condensate; precooler 30 is shaped in the form of a loop to maintain a secure liquid seal between the shells 4 and 5 thus permitting different pressures to be maintained in such shells without escape of vapour.

A suitable purge arrangement 32 is provided to purge condenser 13 and absorber 6 of air or other non-condensible gases. Purge 32 may operate intermittently or continuously as desired.

Shell 4 contains absorber 6 and evaporator 7. The arrangement is shown in Figures 1 and 4. Evaporator 7 consists of horizontally extending side walls 33 and end walls (not shown) which serve to form a box-like compartment 34 supported at the end walls 35 of shell 4. Eliminators 36 are disposed adjacent the top of compartment 34 and extend longitudinally thereof. The eliminators 36 serve to prevent any drops of water entrained by the flashed vapour from being carried over to absorber 6 and return them to compartment 34.

Spray arrangement 10 is disposed between the eliminators 36 and receives chilled water or other medium returning from the air conditioning device and discharges it in compartment 34. A section 37 of compartment 34 is extended downward as shown in Figure 4; such arrangement permits the cooled water to be drained readily from compartment 34 through line 11 without requiring the maintenance of a high water level in compartment 34.

Spray arrangement 10, as shown in Figure 6, consists of a header 38 which extends longitudinally of compartment 34. Preferably, header 38 is provided with a plurality of fan-shaped spray nozzles 39 disposed on opposite sides of header 38. Nozzles 39 are disposed in a position such that the sprays are placed in a vertical plane. This particular arrangement provides an adequate surface of water for evaporation and does not interfere with the vapour flowing upward. The result of the spray arrangement is a reduced entrainment of liquid drops or particles by the vapour.

Header 38, preferably, includes an inner pipe 40 (refer to Figure 8) having openings 41 therein, disposed in a second or outer pipe 42 which carries fan-shaped nozzles 39. Nozzles 39 are arranged at opposite sides of and adjacent the bottom of pipe 42; the openings 41 in pipe 40 may be disposed at the sides thereof. This arrangement permits a reduction in approach velocity of the water entering header 38 and assures adequate and equal distribution thereof among all the nozzles 39.

If desired, nozzles 39 may be disposed at an angle to permit the sprays therefrom to meet the walls 33 of compartment 34. If desired, the nozzles may be adjusted in such manner that the sprays are absorbed by water at the bottom of compartment 34. In either case, the arrangement reduces the amount of liquid entrained and permits flash cooling without interference with the flashed vapour.

In Figures 11 and 12, is disclosed a modified form of spray arrangement in which the fan-shaped spray nozzles are eliminated. In place thereof a plurality of pairs of openings 43 and 43' are formed in pipe 42; the openings in each pair are disposed at an acute angle from a perpendicular line drawn therebetween and extend toward one another. The spray arrangement so provided reduces the amount of liquid entrained and permits flash cooling without interference with the flashed vapour.

The absorber (refer to Figure 4) comprises a coil of tubes or pipes 44 which is arranged between the walls of shell 4 to permit downward flow of vapour passing between the tubes 44. The tubes 44 of absorber 6 preferably, are staggered as illustrated in Figure 4 in order to provide uniform distribution of sprayed liquid over the surfaces of the tubes. Preferably, tubes or pipes 44 are arranged in

such manner as to form when viewed in section an isosceles triangle with the larger axis of the corresponding rhombus extending horizontally. Such arrangement, as pointed out above, permits each vertical row of tubes 44 to receive a substantially equivalent amount of sprayed liquid which assures uniform distribution and complete wetting of the tube surfaces.

The spray arrangement 45 used to spray strong solution over the tubes 44 of absorber 6 is shown in Figures 13, 14 and 15. Spray arrangement 45 includes a header 46 through which the strong solution is drawn from line 25. From header 46 strong solution passes into one or a plurality of pipes 47 which contain solid cone nozzles 48 placed at desired angles to a horizontal plane to permit each nozzle to cover a greater coil surface. Each nozzle 48 distributes the spray uniformly over a cross sectional area of the absorber tubes. Such arrangement of nozzles permits the solution to flow horizontally along the tubes 44 as well as vertically between the tubes thus increasing the rate of heat transfer and permitting uniform wetting of the absorber coil, as well as requiring less space between the spray means and the tubes.

The vapour formed by the flash cooling of refrigerant in evaporator 7 flows upwardly in evaporator 7, passes through eliminators 36 and then flows downwardly exteriorly of and surrounding compartment 34 and is absorbed by the strong solution sprayed over the tubes of the absorber. The strong solution sprayed over the tubes of the absorber is cooled by cooling water passing through tubes 44 of the absorber to aid in rapid absorption of the refrigerant. Preferably the tubes 44 are arranged some distance away from the lowest point of shell 4 in order to provide adequate space for storage of liquid in shell 4 in case of an increase in volume of solution in the shell 4.

As described above the generator 12 and condenser 13 are placed in shell 5 which is secured by the framework of the assembly in position above shell 4. Such arrangement of the condenser and the generator eliminates external vapour connections between them and increases the efficiency of the system. Shell 5 is provided with a longitudinally extending trough 49 into which the weak solution is passed. Openings 49^1 are provided in shell 5 at intervals to distribute weak solution uniformly throughout the length of generator 12. So distributing weak solution throughout the generator improves the efficiency of the device since inefficient preheating is eliminated. I have found that so distributing the weak solution at a plurality of points longitudinally of the horizontally extending generator decreases the preheating period over that required if all weak solution is passed into one end of the generator and permitted to flow longitudinally of the generator since there is an increase in heat transfer to the liquid due to turbulence. The generator is heated to evaporate the refrigerant from the weak solution by means of steam directed through the tubes 50 from steam line 51, the steam being withdrawn from tubes 50 through steam line 52.

Condenser 13 is disposed in position longitudinally of shell 5 above generator 12. Preferably, condenser 13 is placed freely on the supports to obviate disadvantages which might flow from unequal contraction and expansion of the supports. Condenser 13 consists of a longitudinally extending box-like tank or compartment 53 enclosing a coil formed of tubes 54. Cooling water is passed through the coil 54 from line 28 and is discharged therefrom through line 28^1. Eliminators 55 are disposed along the sides of condenser 13 and serve to prevent entrainment of drops of liquid, which might be carried by vapour flowing from the generator 12 upwardly to condenser 13.

As described above, the condenser tank 53 is so supported in shell 5 as to permit independent contraction and expansion thereof. The condenser tank 53, baffles and eliminators 55 are formed as an independent unit which may be slipped freely within the shell 5 to rest on supports therein. As illustrated in Figures 19, 20 and 21, end plates 90 and 90^1 are welded to the ends of shell 5. Each end plate is shaped to conform to the contour of tank 53. At approximately the center longitudinally of shell 5 a support plate 91 is disposed which may be welded to the shell. Plate 91 is provided with an extended portion 92 shaped to the contour of tank 53 and is adapted to form a seat for tank 53. Plate 91 is also provided with an extended portion 93 which forms in effect a tube sheet adapted to support at least some of the tubes of the generator.

In assembling tank 53 with shell 5, tank 53 is slid within the shell and has one end thereof resting on end plate 90. The central longitudinal portion of tank 53 rests on and is supported by plate 91. The opposite end of tank 53 rests of the second end plate 90^1 and is supported thereby. It will be noted that tank 53 is not attached to its supports but is held

in position thereby since the end plates conform to the contour of tank 53. Such method of assembly permits expansion and contraction of tank 53 independently of shell 5.

In the operation of the generator, weak solution is distributed therein at a plurality of points as described above. A portion of the refrigerant in the weak solution is boiled out and passes upwardly in shell 5 through eliminators 55 and is condensed in condenser 13, being removed from the condenser 13 through line 29 to condensate precooler 30 and then being returned to the evaporator 7; the strong solution remaining in generator 12 is withdrawn therefrom through line 20 as previously described.

A pressure equalizer line 56 is provided connecting shell 5 with an overflow arrangement 21. As shown in chain lines in Figures 2 and 3, the line 56 may be connected at the top of shell 5; where, however, the line 56 is also used to aid in preventing too high a liquid level in generator 12, it is connected at the side of the shell. When the liquid level in generator 12 rises, some portion of the liquid is drained through line 56 to overflow arrangement 21 which returns the solution through line 22, *et cetera*, to the absorber 6.

It is desirable that the refrigerating capacity be changed immediately upon change in load to attain most satisfactory operation. The temperature of the chilled water may be used to indicate a change in load since a decrease in the temperature thereof from a predetermined point indicates that the load imposed upon the system has decreased. As the temperature of the chilled water leaving the evaporator decreases, the capacity of the system may be decreased accordingly by throttling the volume of strong solution passing to the absorber.

For this purpose, a valve 57 is placed in line 16 between ejector 24 and pump 14, at a point between pump 14 and the juncture of line 17 with line 16 (refer to Figure 1). Valve 57 is actuated by a control 58 operated by a bulb 59 placed in or adjacent to line 11. As the temperature of chilled water passing through line 11 decreases, fluid in bulb 59 contracts and control 58 in accordance therewith tends to move valve 57 toward a closed position thereby decreasing the amount of weak solution being forwarded to generator 12 through lines 17 and 19 proportionately to the decrease in the temperature of the chilled water. Movement of valve 57 toward a closed position also decreases proportionately the amount of weak solution passing to ejector 24. The reduction in the amount of weak solution passing to ejector 24 reduces the velocity of such solution through the nozzle of the ejector and consequently a smaller quantity of strong solution is entrained or induced from line 23. The throttling action of valve 57 reduces the amount of solution passing to and returning from generator 12 and likewise reduces the amount of solution passing to ejector 24 and forwarded to the absorber 6. The absorbing capacity of absorber 6 is controlled by the decreased wetting action provided by the reduced rate of flow of combined solution and by the reduced rate of flow of strong solution therein in accordance with the load imposed on the system.

A valve 60 is provided in steam line 51 to control the amount of steam passing into the tubes 50 of generator 12 in accordance with the load imposed upon the system. Valve 60 is actuated by control 61 operated in turn by a bulb 62 disposed in or adjacent to line 20. The amount of condensing water passing through condenser 13 is controlled by means of a valve 63 placed in line 28^1, actuated by a thermostat 64 controlled by a bulb 65 disposed in or adjacent to vapour condensate line 29. It will be understood valve 63 may be disposed in position in line 28 if desired; when cooling water is passed in series through the tubes of the absorber and the tubes of the condenser, valve 63 may be disposed in line 27 if desired. If cooling water is passed in parallel lines through the tubes of the absorber and the tubes of the condenser, a similar valve may be provided in the line supplying cooling water to the tubes of the absorber or in the line through which such water is withdrawn.

The concentration of the strong solution leaving generator 12 depends upon the temperature and pressure of solution in shell 5. Pressure in shell 5 may be maintained indirectly through the control of the condenser 13. The pressure in shell 5 is dependent upon the condensing temperature of the condenser 13. As the temperature of the vapour condensate in line 29 decreases it serves as an indication that too large an amount of condensing water is being permitted to flow through the coil 54 of condenser 13. Bulb 65 through thermostat 64 throttles valve 63 to decrease the amount of condensing water flowing through the coil 54 of condenser 13. The condensing temperature may be controlled by regulating the temperature of the cooling water within desired limits.

As the load reduces and the amount of solution passing from the generator

reduces, the temperature of the strong solution in line 20 increases; the increase in temperature indicates that too much steam is being supplied to generator 12 heating the solution and increasing its concentration to an extent not required. Bulb 62 responding to the temperature of the solution in line 20 through control 61 actuates valve 60 to move toward a closed position to throttle the amount of steam passing through the coil 50 of generator 12 until it balances with the new load. By means of valves 60 and 63, temperature and pressure of the solution in shell 5 is controlled and thereby indirectly provides control of concentration of solution.

While generally it is desirable to maintain the concentration of the solution constant in accordance with temperature and pressure conditions in the shell 5, in some cases it may be desirable to decrease the concentration of the solution at partial load. For this purpose a suitable reset control is provided to change the control point of control 61; control 61 may then be actuated by air pressure through line 66[1] connected to air line 66 which operates valve 63 or if desired by air pressure through line 66[11] connected to the air line which operates valve 57. The reset control so provided serves to change the control point of control 61. As air pressure in line 66[1] decreases, it resets the control point of control 61 in accordance with the desired temperature of the solution leaving the generator and pressure in shell 5 thereby indirectly decreasing the concentration of the solution to the desired degree.

Purge arrangement 32 includes a housing or casing 67 containing a condensing coil 68 through which condensing water is passed. A steam line 70 is connected to housing 67 as shown in Figure 1 and an ejector 71 is disposed in line 70. A purge pipe 72 extends longitudinally of absorber 6 and has openings therein to suck in air and other non-condensible gases collecting in absorber 6. Pipe 72 is connected by means of line 73 to ejector 71. A valve 73[1] is disposed in the line to permit it to be closed normally when desired. Passage of steam through ejector 71 entrains air and other non-condensible gases from absorber 6 through line 73 when valve 73[1] is open; the steam and entrained gases are carried into housing 67 where a large part of the steam is condensed by its heat exchange relation with the water in coil 68.

Housing 67 is also connected by means of line 74 to a purge pipe 75 which extends longitudinally of condenser 13 and has openings therein to gather air and other non-condensible gases collecting in condenser 13. Pressure in housing 67 is less than pressure in shell 5. Consequently air and other non-condensible gases flow through line 74 to housing 67. A valve 74[1] is disposed in line 74 to permit it to be closed when desired. Likewise suitable valves (not shown) may be disposed in steam line 70 if desired and in water line 75[1] hereinafter described.

An auxiliary water line 75[1] is provided in which is placed a water ejector 76 connected to housing 67 by line 77. Passage of water through ejector 76 entrains the liquid and gases in housing 67 thus assuring their removal from the system. The steam and water used to actuate the purge may be obtained from the same sources of supply used to provide the generator with steam and the absorber and condenser with cooling water, their connecting pipes being omitted from Figs. 2 and 3.

The purge arrangement described may operate either intermittently or continuously as desired; it has been found that the absorption system described may be maintained in a condition substantially free from non-condensible gases by intermittent operation of the water and steam ejector purge arrangements.

It will be noted the condenser 67 of purge arrangement 32 is disposed some distance above absorber 6. Such position of purge 32 is of particular value when, as occurs under some circumstances, the liquid level in absorber 6 rises above purge pipe 72. The power of ejector 71 is such that under such conditions it cannot raise liquid to a height sufficient to withdraw solution from the system but is adequate to withdraw air and other non-condensible gases from absorber 6 when the liquid level in the absorber is such as to permit such gases to be withdrawn through purge pipe 72. Even though the liquid level in the absorber 6 is above pipe 72, operation of purge 32 does not remove liquid from the absorber.

In Figures 22 and 23, is illustrated the manner in which the purge pipe is disposed in the absorber 6 and is secured in place therein to prevent leakage from the absorber to the ambient atmosphere. The purge pipe 72 extends longitudinally of absorber 6 and is supported at one end of the absorber by means of a cradle 95 welded to shell 4. The end of pipe 72 rests on cradle 95 and is supported thereby but it is not attached to the cradle. At the opposite end, purge pipe 72 passes through the wall 35 of shell 4 and

through the wall 97 of water header 98 provided to supply cooling water to the absorber. An opening is formed in wall 35 and is threaded to recceive a bushing 99 welded to tube 72. When assembling the purge pipe in the structure the bushing is coated with a suitable sealing composition and is screwed into the threaded opening in wall 35 thus serving to close and to seal the opening between the absorber and header 98. An opening is formed in wall 97 of header 98 through which purge pipe 72 passes. At least a portion of the wall of such opening is threaded to receive a gland 100. A packing ring 101 is disposed about pipe 72 within such opening and is compressed in place by means of gland 100 thus securely sealing the opening between the header and the ambient atmosphere to prevent leakage of water during operation of the machine.

It will be noted (refer to Figure 1) that line 23 has at least a portion thereof disposed in the form of a loop 23^1. Ejector 24 is disposed in a plane below the plane in which heat exchanger 18 extends. Loop 23^1 serves to prevent the heat exchanger 18 from running dry during operation of the machine even when the liquid level in line 22 drops excessively. Loop 23^1 serves to assure that an adequate quantity of strong solution is present in exchanger 18 at all times for heat exchange purposes.

Heat exchanger 18 is shown in Figures 16, 17 and 18. Heat exchanger 18 includes a plurality of connected pipes 78 for the passage of strong solution. Disposed in each of said pipes is a plurality of smaller pipes 79 bundled together for the passage of weak solution from absorber 6 to generator 12. Pipes 79 are held in spaced position by means of wires disposed at intervals along the length thereof. Referring to Figures 17 and 18 it will be noted that wires 80 are disposed about the innermost pipe 79 at intervals along its length. A plurality of pipes 79 are disposed thereabout and wires 81 at spaced intervals serve to hold such pipes in spaced position to the innermost pipe. A plurality of pipes 79 are disposed thereabout and wires 82 at spaced intervals serve to hold such pipes in desired position. The wire supports so provided permit pipes 79 to be spaced from one another thus assuring adequate heat exchange relation between strong solution passing through pipes 78 and weak solution passing through pipes 79. Strong solution is passed into heat exchanger 18 at point 83 connected to line 22 and is removed therefrom at point 84 connected to line 23. Weak solution is passed into exchanger 18 from line 17 and is removed therefrom through line 19.

It is desirable for long life of service that elements of the device which come into contact with the solution be formed of or coated with corrosion inhibiting materials. If the elements contacted by the solution are not resistant thereto, it will be appreciated that excessive deterioration in long continued service may be encountered and it will be necessary to make frequent replacement of parts. Accordingly, in the preferred system, the elements which contact the solution are formed of corrosion inhibiting materials. For example the drums or shells may have their interior surfaces covered with stainless steel. The tubes of the absorber may be formed of cuprinickel while the tubes of the condenser may be formed of a suitable copper alloy such as that sold under the Registered Trade Mark " Everdur ". The evaporator and condenser tanks may be formed of copper alloys such as " Everdur " or brass. The eliminators may be formed of stainless steel or cuprinickel. Other elements of the system in contact with the solution may also be formed of cuprinickel or stainless steel.

A desired amount of weak solution is withdrawn from the absorber and combined with a proportionate amount of strong solution to be passed to the absorber in accordance with the load imposed upon the system.

An advantage of the present system resides in the division of weak solution to the generator and the absorber which serves to improve the performance and increase efficiency of the system. Arranging the absorber below the evaporator serves to concentrate non-condensible gases at the bottom of the absorber so that such non-condensible gases can be removed easily from the system through the purge arrangement. Another advantage is derived from positioning the absorber above the pumps and the generator above the ejector. Such arrangement provides additional head which decreases the capacity of pumps required for the system thereby decreasing operating costs.

This system is lighter in weight thus reducing shipping costs and permitting more ready and speedy assembly of the system for use. Apart from the pumps it does not contain any primary moving parts thus considerably increasing its serviceable life, does not vibrate in operation, and eliminates the dangers of extremely high pressures commonly maintained in absorption systems.

The spraying arrangement used for spraying water in the evaporator is so designed as to assure uniform distribution of water throughout the evaporator and a uniform distribution of spray in the evaporator without interference with flashed vapour arising from the evaporator. The spray arrangement used for spraying solution over the coil of the absorber assures an equal distribution of solution thereover thus improving the performance of the system.

The arrangement of the evaporator and absorber in a single shell enhances the economy and simplicity of the system. Vapour arising from the evaporator is directed to the absorber in such manner that it surrounds the exterior walls of the evaporator and in effect insulates the evaporator against the surrounding atmosphere. Additional insulation need not be disposed on the shell containing the evaporator in order to insulate the same, since the arrangement so provided is adequate to insulate the evaporator from the ambient atmosphere.

The control arrangements embodied in the present invention are described and claimed in the co-pending Application No. 18379/47 (Serial No. 639,416).

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A continuous cycle absorption refrigeration system, comprising in combination a shell, a member in said shell co-operating with the shell to form an absorber, a second member in the shell co-operating therewith to form an evaporator, said shell having means for maintaining a predetermined pressure therein, a second shell disposed adjacent the first shell, a member in said second shell co-operating therewith to form a generator, an element in said second shell co-operating therewith to form a condenser, said second shell having means for maintaining a predetermined pressure therein different from the pressure in said first shell the shells being adapted to be sealed from one another in respect of flow of vapour, and means for circulating solution between the separate shells.

2. A refrigeration system according to Claim 1, in which the evaporator is adapted to flash-cool refrigerant and the absorber is adapted to absorb flashed vapour passing thereto from the evaporator, whilst the generator serves to vaporise refrigerant which is then condensed in the condenser.

3. A refrigeration system according to Claim 1 or Claim 2, in which one or both shells are disposed horizontally.

4. A refrigeration system according to any of Claims 1 to 3, in which means are provided for purging the condenser and the absorber of non-condensible gases.

5. A refrigeration system according to any of Claims 1 to 4, in which means are provided for maintaining a desired level of solution in the generator.

6. A refrigeration system according to any of Claims 1 to 5, having a pump for withdrawing weak solution from the absorber and forwarding it to the generator, and an ejector, said pump serving to pass a portion of weak solution into the ejector, the discharge of weak solution in the ejector serving to entrain strong solution from the generator to form a mixture of weak and strong solution and to supply the mixture to the absorber.

7. A refrigeration system according to Claim 6, in which the second shell is disposed above the first shell, a line connecting the generator and the absorber, said line including the said pump, and a second line connecting the absorber and the generator, an overflow arrangement being disposed in said second line, said second line also including the said ejector.

8. A refrigeration system according to Claim 7, in which a heat exchanger is provided which is adapted to place strong and weak solution in the said lines in heat exchange relation to one another.

9. A refrigeration system according to Claim 4, in which the means for purging the condenser and the absorber of non-condensible gases comprise a housing, a steam line connected to the housing, an ejector in said steam line, a line connecting the ejector with the absorber whereby passage of steam at high velocity to said injector is adapted to entrain gases from said line, a cooling coil in said housing adapted to condense steam discharged into the housing, a second line connecting the condenser with the housing so that higher pressure in the condenser shell will force non-condensible gases into said housing, a water line, a second ejector disposed in said water line, and a line connecting said housing to said second ejector, passage of water at high velocity through said second ejector serving to entrain liquid and gases in said housing and discharge the same from the system.

10. A refrigeration system according to any of Claims 1 to 9, having a line which connects the condenser and the evaporator for returning vapour condensate to the evaporator in which line

The spraying arrangement used for spraying water in the evaporator is so designed as to assure uniform distribution of water throughout the evaporator and a uniform distribution of spray in the evaporator without interference with flashed vapour arising from the evaporator. The spray arrangement used for spraying solution over the coil of the absorber assures an equal distribution of solution thereover thus improving the performance of the system.

The arrangement of the evaporator and absorber in a single shell enhances the economy and simplicity of the system. Vapour arising from the evaporator is directed to the absorber in such manner that it surrounds the exterior walls of the evaporator and in effect insulates the evaporator against the surrounding atmosphere. Additional insulation need not be disposed on the shell containing the evaporator in order to insulate the same, since the arrangement so provided is adequate to insulate the evaporator from the ambient atmosphere.

The control arrangements embodied in the present invention are described and claimed in the co-pending Application No. 18379/47 (Serial No. 639,416).

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A continuous cycle absorption refrigeration system, comprising in combination a shell, a member in said shell co-operating with the shell to form an absorber, a second member in the shell co-operating therewith to form an evaporator, said shell having means for maintaining a predetermined pressure therein, a second shell disposed adjacent the first shell, a member in said second shell co-operating therewith to form a generator, an element in said second shell co-operating therewith to form a condenser, said second shell having means for maintaining a predetermined pressure therein different from the pressure in said first shell the shells being adapted to be sealed from one another in respect of flow of vapour, and means for circulating solution between the separate shells.

2. A refrigeration system according to Claim 1, in which the evaporator is adapted to flash-cool refrigerant and the absorber is adapted to absorb flashed vapour passing thereto from the evaporator, whilst the generator serves to vaporise refrigerant which is then condensed in the condenser.

3. A refrigeration system according to Claim 1 or Claim 2, in which one or both shells are disposed horizontally.

4. A refrigeration system according to any of Claims 1 to 3, in which means are provided for purging the condenser and the absorber of non-condensible gases.

5. A refrigeration system according to any of Claims 1 to 4, in which means are provided for maintaining a desired level of solution in the generator.

6. A refrigeration system according to any of Claims 1 to 5, having a pump for withdrawing weak solution from the absorber and forwarding it to the generator, and an ejector, said pump serving to pass a portion of weak solution into the ejector, the discharge of weak solution in the ejector serving to entrain strong solution from the generator to form a mixture of weak and strong solution and to supply the mixture to the absorber.

7. A refrigeration system according to Claim 6 in which the second shell is disposed above the first shell, a line connecting the generator and the absorber, said line including the said pump, and a second line connecting the absorber and the generator, an overflow arrangement being disposed in said second line, said second line also including the said ejector.

8. A refrigeration system according to Claim 7, in which a heat exchanger is provided which is adapted to place strong and weak solution in the said lines in heat exchange relation to one another.

9. A refrigeration system according to Claim 4, in which the means for purging the condenser and the absorber of non-condensible gases comprise a housing, a steam line connected to the housing, an ejector in said steam line, a line connecting the ejector with the absorber whereby passage of steam at high velocity to said injector is adapted to entrain gases from said line, a cooling coil in said housing adapted to condense steam discharged into the housing, a second line connecting the condenser with the housing so that higher pressure in the condenser shell will force non-condensible gases into said housing, a water line, a second ejector disposed in said water line, and a line connecting said housing to said second ejector, passage of water at high velocity through said second ejector serving to entrain liquid and gases in said housing and discharge the same from the system.

10. A refrigeration system according to any of Claims 1 to 9, having a line which connects the condenser and the evaporator for returning vapour condensate to the evaporator in which line



are provided the sealing means for sealing the shells in respect of vapour one against the other.

11. A refrigeration system according to Claim 9, in which connections are provided so that steam supplied to the steam ejector can be withdrawn from the source of supply which supplies steam to the generator and water supplied to the water ejector can be withdrawn from the source of supply which provides cooling water to the absorber.

12. A refrigeration system according to any of Claims 1 to 11, having means for spraying refrigerant in the evaporator, said spray means comprising a member adapted to receive refrigerant, a second member surrounding said first member said first member having a plurality of openings therein connecting the interior thereof with the interior of said second member, a plurality of fan-shaped spray nozzles connected to said second member adapted to discharge refrigerant in a series of substantially uniform sheet-like sprays, the openings in said first member being disposed a sufficient distance above the fan-shaped spray nozzles of said second member to permit refrigerant to accumulate in the base of said second member adjacent the fan-shaped spray nozzles, thereby reducing the turbulence of refrigerant flow in the second member and its velocity of discharge from said nozzles.

13. A refrigeration system according to Claim 12, in which the longitudinal axis of the first member is disposed in a plane above the plane of the longitudinal axis of the second member to provide space for the accumulation of fluid in said second member.

14. A refrigeration system according to Claim 12 or Claim 13, in which the fan-shaped spray nozzles are comprised by a plurality of spaced openings in the second member arranged in pairs therein to discharge refrigerant in a substantially uniform sheet-like spray, the openings of each pair extending through the wall of the respective member toward one another and at an acute angle from a perpendicular line drawn therebetween.

15. A refrigeration system according to Claim 8, in which the heat exchanger comprises a bundle of pipes disposed in spaced relation through which one of said solutions is passed, spaced members disposed about the innermost pipe of said bundle, a layer of pipes disposed about said innermost pipe in spaced relation to one another and spaced from the innermost pipe by said members, second members disposed at spaced positions about said layer, a second layer of pipes disposed thereabout in spaced relation to one another and spaced from the first layer by said members, third members disposed about said second layer, and a pipe enclosing the bundle through which the other of said solutions is passed, said pipe being held in spaced relation to said bundle by the outer members disposed thereabout.

16. A refrigeration system according to any of Claims 2 to 15, in which the evaporator and absorber are so arranged that flashed vapour is adapted to pass to the absorber about the evaporator and thus insulate the latter against the temperature of ambient atmosphere.

17. A refrigeration system according to any of Claims 1 to 16, in which the absorber, the generator and the condenser each comprise tubes, and means are provided for passing a heating medium through the tubes of the generator and a cooling medium through the tubes of the condenser.

18. A refrigeration system according to Claim 17, in which the generator and condenser shell includes a trough-like portion to receive solution from the absorber and distribute it among the tubes of the generator, a line being provided which connects the said trough-like portion and the absorber.

19. A refrigeration system according to Claim 17 or Claim 18, in which the evaporator and absorber shell and the generator and condenser shell each have an interior formed of stainless steel, the evaporator is formed of corrosion-inhibiting copper alloy, the tubes of the absorber and the generator consist of cupronickel, and the condenser tubes are formed of copper alloy.

20. A refrigeration system according to any of Claims 17 to 19, in which the tubes of the absorber are arranged in staggered relation to one another.

21. A refrigeration system according to Claim 20, in which at least some of the tubes of the absorber are arranged to form a triangle having at least two equal sides, with the larger axis of a corresponding rhombus extending horizontally.

22. A refrigeration system according to Claim 7 or Claim 8, in which the line connecting the generator with the absorber, is provided in a part thereof disposed between the heat exchanger and the absorber with a loop which is adapted to retain an adequate supply of strong solution for heat exchange purposes in the heat exchanger.

23. A refrigeration system according to any of Claims 1 to 26, in which the

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condenser includes a tank for the reception of condensate disposed in the respective shell, said tank having supporting means to permit of contraction and expansion thereof independently of the said shell, said supporting means including end members attached to said shell, said members being shaped to conform to the contour of said tank, and an intermediate supporting member shaped to conform to the contour of said tank, said support member being secured to said shell.

24. A refrigeration system according to Claim 9 or Claim 11, in which a water header is provided at one end of the absorber and evaporator shell for supplying cooling water to the absorber, the wall of said header having an opening therein and the line connecting the purge ejector and the absorber for withdrawing non-condensible gases from the absorber passing through said opening and through the wall of the absorber and evaporator shell, means being provided for sealing the connection between the purge line and the header, said means including a thread formed in the wall surrounding the header opening, packing means disposed in said opening, and means adapted to co-operate with said thread to compress said packing means thereby rendering the opening secure against leakage.

25. A refrigeration system according to Claim 24, in which a bushing secured to the purge pipe co-operates with the thread to hold the pipe in position, a shoulder being provided in the header opening against which the packing means rests, the packing means being pressed against the shoulder by a gland.

26. A continuous cycle absorption refrigeration system according to Claim 1, having its parts arranged substantially as described with reference to the accompanying drawings.

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