Jan. 10, 1967 M. K. ROHRS ETAL 3,296,824

MULTIPLE PUMP SYSTEM FOR ABSORPTION APPARATUS

Filed Oct. 21, 1964 3 Sheets-Sheet 1

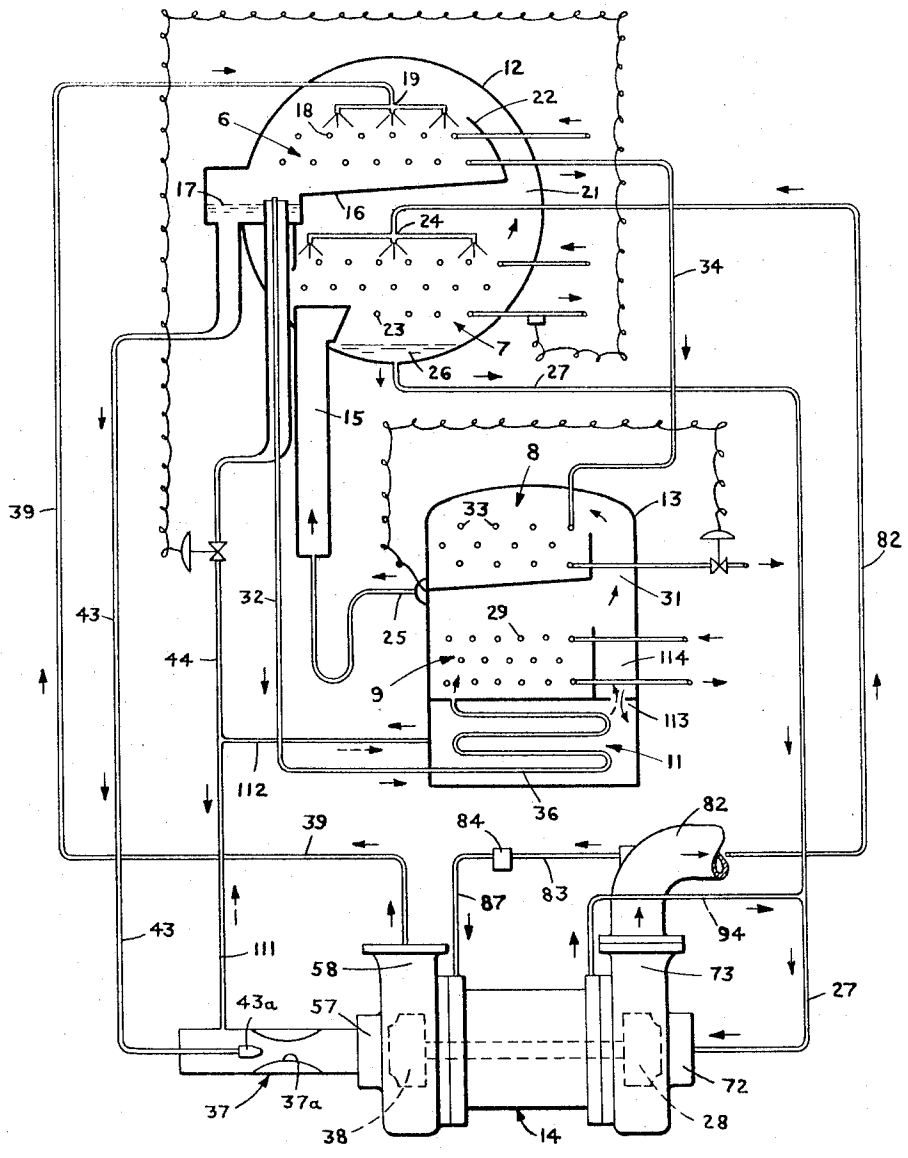


FIG. 1

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Filed Oct. 21, 1964 3 Sheets-Sheet 2

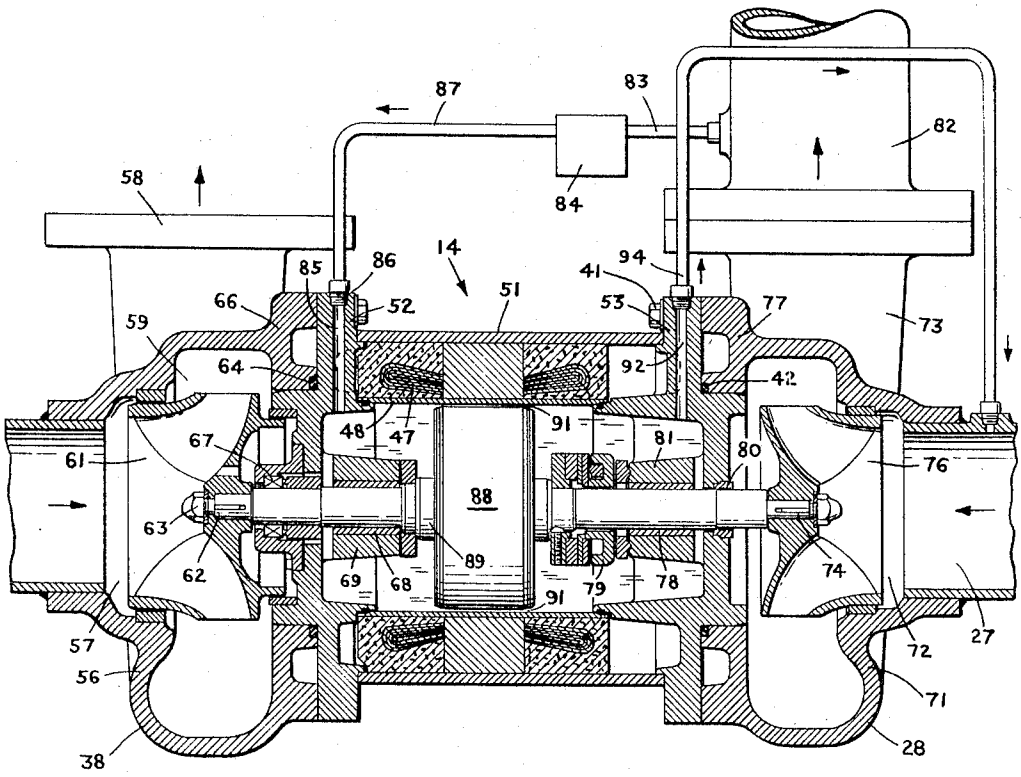


FIG. 2

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MULTIPLE PUMP SYSTEM FOR ABSORPTION APPARATUS

Filed Oct. 21, 1964 3 Sheets-Sheet 3

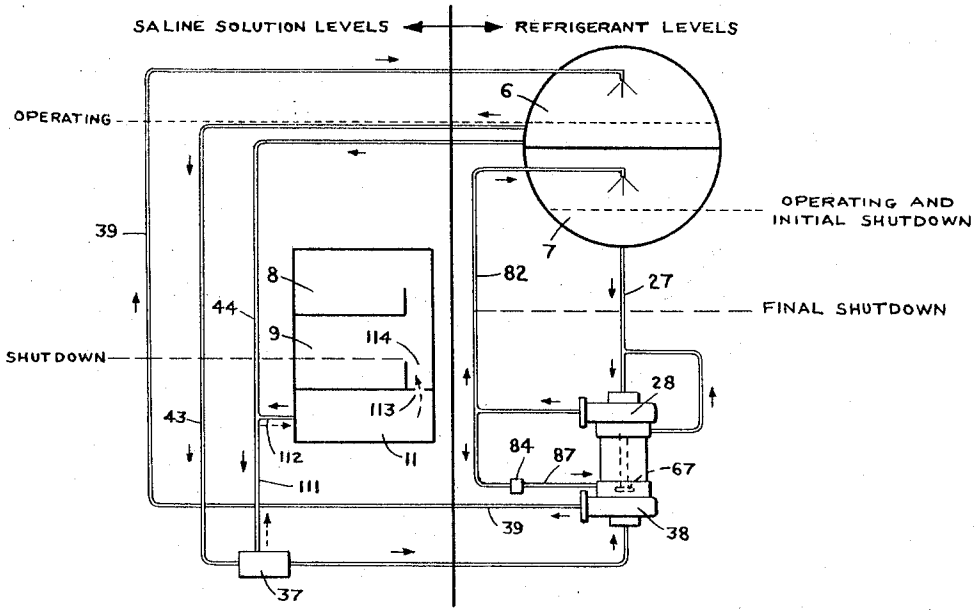


FIG. 3

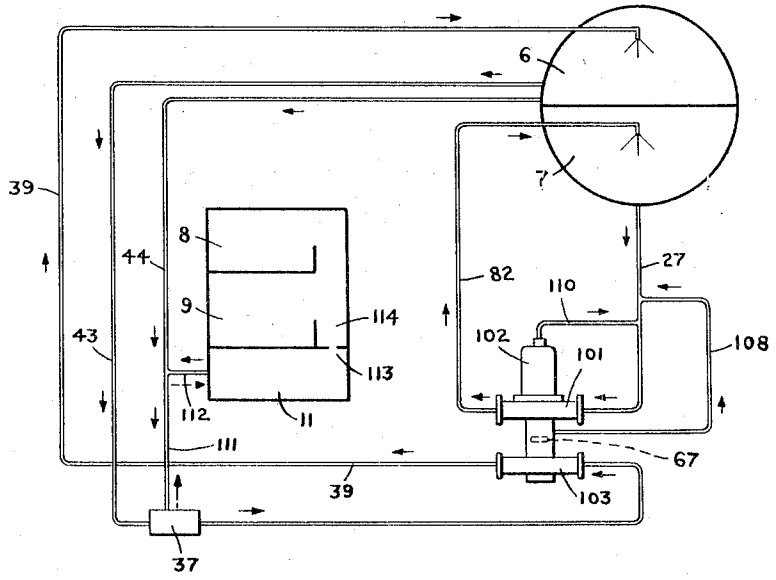


FIG. 4

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3,296,824

MULTIPLE PUMP SYSTEM FOR ABSORPTION APPARATUS

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8 Claims. (Cl. 62—487)

This invention relates to an absorption refrigeration system. It relates in particular to such a system circulating a saline solution including a hydrophilic salt in a refrigerant, which system includes pump means for separately carrying said solution and a refrigerant through parts thereof.

Absorption systems of the type contemplated include basically an absorber, an evaporator, a generator, and a condenser interconnected into a closed system and circulating brine solution comprising a hydrophyiic salt and a refrigerant such as water. System components are normally so connected to separately circulate the saline solution through one portion thereof and to circulate refrigerant through another portion.

One characteristic of this type of system is that both portions function under pressure less than atmospheric. Consequently, apparatus embodying the absorption arrangement of necessity must be vapor or air-tight to avoid a leak of the atmosphere which would hamper efficiency of the system.

Since the system works under reduced pressure conditions it is essential to avoid air in-leak not only through shells and casings enclosing the refrigeration apparatus, but also through moving parts such as pumps, shafts, valves and the like.

As a practical consideration, circulation of liquid through the system is achieved preferably by means of a hermetically driven pump arrangement having suitable sealing means associated therewith to avoid in-leakage of air. In the present arrangement, a single motor is coupled to a plurality of pumps, each of which separately circulates saline solution and refrigerant so as to keep the two liquid components substantially separated.

The present invention further provides means in the absorption system described for efficiently and separately pumping saline solution and refrigerant in such manner that the drive motor coupled to the respective pumps is effectively cooled and lubricated by contact with circulated refrigerant only. Also provided is means for bleeding an amount of refrigerant into the saline circulating pump to dilute solution in the latter. This bleeding of refrigerant not only avoids passage of absorbent into the drive motor while operating, but also avoids such leakage during prolonged periods of time when the apparatus is inoperative. Thus, by avoiding contact of motor parts with the saline solution, the drive motor is both cooled and lubricated and also protected from undesirable plating which would result from contact with the absorption solution.

It is therefore an object of the invention to provide a novel pump means for an absorption refrigeration system in which saline solution and refrigerant are separately circulated therethrough.

A further object of the invention is to provide a pump arrangement of the type contemplated in which refrigerant is circulated through a refrigerant pump and to the pump drive motor, for cooling the latter and for maintaining motor parts out of contact with the absorbent solution.

A still further object of the invention is to provide a pumping system embodying a plurality of pumps driven by and coupled to a single drive motor, the latter being

cooled by contact with refrigerant passed through at least one of said pumps without contacting absorbent solution carried in the other pump.

Another object of the invention is to provide a motor driven liquid pumping arrangement in an absorption system whereby during non-operative periods of the system a liquid head maintained by refrigerant in the system will be greater than the liquid head maintained by saline solution, thereby precluding passage of said absorbent solution into portions of the refrigerant pump and the motor.

These and other objects and advantages of the invention will become apparent to one skilled in the art from the following description of several embodiments of the invention and the novel features will be particularly pointed out hereinafter in the claims.

In the drawings:

FIGURE 1 is a diagrammatic representation of an improved absorption system having an upper shell and a lower shell enclosing refrigeration components, and having pump means external to the shells for circulating solution and refrigerant through the system.

FIGURE 2 is an enlarged view in cross section of one embodiment of the novel motor pump arrangement for passing liquid refrigerant through the system shown in FIGURE 1.

FIGURE 3 is a schematic representation of the system shown in FIGURE 1 illustrating another improved motor pump arrangement and shows generally the different liquid levels of the system during operation and following shut down.

FIGURE 4 is a schematic representation of the system shown in FIGURE 1 illustrating still another improved motor pump arrangement.

In the embodiment of invention shown in FIGURE 1, the absorption system includes the essential elements of an absorber **6** and evaporator **7**, a condenser **8** and a generator **9**, and heat exchanger **11**. These elements are separately carried in an upper shell **12**, at a lesser pressure, and a lower shell **13**, as a higher pressure; both of which shells operate at a pressure substantially below atmospheric. An improved motor-pump unit **14**, disposed external shells **12** and **13**, communicates with the upper and lower portions thereof for circulating separate streams of refrigerant, and a saline solution comprising a hydrophylic salt. For convenience, it will be assumed that the refrigerant is water and the hydrophylic salt is lithium bromide.

While the improved motor pump unit **14** is shown disposed external to the shells, it is understood that said pumping arrangement may be positioned completely or partially within the shell **13**.

Absorber **6** is separated from evaporator **7** by an elongated pan **16** extending horizontally of the shell **12** and including a depressed sump **17** for holding a quantity of solution. A coil or tube bundle **18** disposed within absorber **6** is connected to a source of cooling liquid to be circulated therethrough. Spray headers **19** are disposed in the upper end of absorber **6** and direct streams of concentrated saline solution into contact with tube bundle **18** and are cooled thereby. Refrigerant in the form of water vapor is passed upwardly into the absorber **6** from evaporator **7** through a lateral passage **21** formed by upstanding edge **22** positioned adjacent to cylindrical wall **12**. The water vapor is absorbed in lithium bromide solution which is thereby diluted prior to its collection in sump **17**.

Evaporator **7** disposed in the lower part of shell **12** includes a cooling coil or tube bundle **23** carrying a stream of fluid to be chilled. Refrigerant is directed into the evaporator through spray header **24** positioned above the tube bundle **23** whereby the refrigerant passes in heat

exchange contact with the surface of said tubes thereby evaporating at least a portion of the refrigerant in the low pressure atmosphere of the upper shell **6** and effecting cooling of the medium passed through tube bundle **23**.

Excess refrigerant falls into the base of evaporator **7**, is accumulated in the sump or reservoir **26**, is thereafter circulated through line **27** to the suction inlet of hermetic pump **28** to be hereinafter described and thence by line **82** into spray header **24** for reintroduction into the evaporator section **7**.

Shell **13** encloses condenser **8**, generator **9** and heat exchanger **11**. Generator **9** includes heating coil **29** positioned in the liquid holding portion of the generator for boiling saline solution to liberate refrigerant from the solution. Refrigerant vapors so released pass upwardly through passage **31** into condenser **8**. Concentrated solution remaining in generator **9** is then gravity fed to the heat exchanger **11** for indirectly contacting cooler diluted solution carried from absorber sump **17** in line **32**, for preheating of said solution prior to introduction thereof to the generator **9**.

Condenser **8** includes a tube bundle **33** circulating a cooling medium such as water which may be connected through line **34** to tube bundle **18** in the absorber. Connection may be made alternative through a cooling tower (not shown) to circulate said cooling medium therethrough. Saturated condensate is then passed through line **15** into evaporator **7** within shell **12** for flashing at least a portion of the condensate into the lower pressure atmosphere within said shell **12**.

During periods of normal operation of the system, there is a continuous circulation of absorbent solution in varying degrees of concentration between absorber **6** and generator **9** through the motor driven pump unit **14**. In coil **36** of heat exchanger **11**, diluted solution is passed in a gravity flow from absorber **6** to generator **9** and thence reconcentrated by removal of at least a portion of the refrigerant. Hot concentrated solution is redirected into the shell side of heat exchanger **11** and thereafter returned to absorber **6** by way of flow mixer **37**, pump **38**, line **39** and spray header **19**.

Vaporized refrigerant passed into absorber **6** from evaporator **7** at the low pressure maintained in the latter, is absorbed by concentrated solution stream sprays directed from spray header **19**, which solution accumulates in sump **17**, as described hereinbefore.

The terms weak solution and concentrated solution hereafter referred to define the property of the saline solution as it passes through the absorption system. For example, solution sprayed into the absorber is normally in the concentrated state. However upon absorbing refrigerant vapor, said solution becomes more dilute due to the relatively greater concentration of refrigerant. Upon leaving the system generator, solution has been separated at least in part from refrigerant therein and is therefore concentrated and characterized by higher absorbent qualities.

Referring to FIGURE 2, pump unit **14** utilized for moving both saline solution and refrigerant through the system may be of the hermetic type and so constructed to permit cooling of the drive motor by contact with refrigerant only. Cooling of the motor and other moving parts by contact with absorbent solution is found to be impractical because of possible damage to said parts due to surface plating as a result of electrolytic action of solution in contact with metal surfaces.

Referring to FIGURE 2, one embodiment of pump motor unit **14** includes a centrally positioned electric motor having opposed outwardly extending overhung shaft ends. The latter are coupled to similar pumps **28** and **38**, the entire unit being hermetically enclosed within a liquid tight casing **51**.

The central motor portion includes generally cylindrical casing **51** having end surfaces which suitably engage opposed flange plates **52** and **53** in sealing relationship therewith. The respective flange plates **52** and **53** may be

fixedly positioned to casings **56** and **71** by means of bolts **41**.

Pumps **28** and **38** are similar in structure; and with specific reference to pump **38** comprise generally a circular casing **56** having a central suction inlet **57** and a discharge **58**. Chamber **59** in casing encloses an impeller **61** keyed to overhung shaft end **62**, said impeller being positioned by a lock nut **63** threadably carried on the shaft end.

Casing **56** includes a back wall **66** having a flat face disposed in sealing engagement with adjacently positioned end flange **52**. A resilient ring **64** is compressively disposed between end flanges **52** and pump wall **66** defining an annular liquid tight seal. Back wall **66** includes a central bore extending therethrough in alignment with a central bore in flange plate **52**.

A seal member **67** is retained within an inner bore of end flange **52** and disposed in contact with shaft end **62** thereby defining a substantially liquid tight seal except for slight leakage therethrough which will be hereinafter delineated in greater detail. The saline pump side of seal **67** is acted on by pressure of solution in the suction side of pump **38**. This pressure is less than that of the refrigerant stream used to cool and lubricate the motor, as more fully described hereinafter.

Sleeve bearing **68** is pressed into place in hub **69** projecting from end plate **52** to rotatably journal shaft end **62**.

Refrigerant pump **28** connected to the opposed end of the drive motor, includes a casing **71** having a suction inlet **72** communicated with the system evaporator through line **27**, and receiving a flow of refrigerant from evaporator sump **26**. Pump **28** discharge outlet **73** is communicated with casing **71**, and passes a stream of refrigerant therefrom by way of line **82** to be returned to evaporator spray header **24**.

Shaft end **74** extending axially of casing **71** fixedly supports impeller **76**. Casing **71** includes a wall **77** sealably engaging end flange **53** by means of circularly spaced bolts **41** to define a peripheral liquid seal at casing **51**. End flange **53** includes a hub **81** extending into casing **51**, positioning sleeve bearing **78** in which shaft end **74** is journaled.

A labyrinth seal **80** is disposed in plate **53** for sealing engagement with shaft end **74**. Dependent on the design clearance of seal **80** a limited amount of refrigerant will flow across the shaft from the pump **28** side into the motor side, wherein it will combine with the refrigerant entering the motor from line **87** prior to its being discharged. Thus, seal **80** effectively prevents the short circuiting of the high pressure discharge flow across the shaft end insures that the refrigerant will flow to cool the motor following the path indicated by the arrows. Of course similar construction as shown for pump **38** could have been used, namely sealing the rearward side of the impeller **76** from discharge pressure and providing a passage for refrigerant at suction pressure, in conjunction with a suitable seal engaging the shaft.

A thrust bearing **79** is carried on shaft **74** to axially position rotor **88** against hub **81** and avoid axial movement during operation of the motor pump unit.

While a particular arrangement of seals and bearing has been shown and described, it will be understood by one skilled in the art that various substitutions may be made such as the use of hydrodynamic bearings or members having either pressure balancing passages therein or designed to operate within the limits of predetermined pressure gradients.

As illustrated in FIGURE 1, the suction inlet **57** of pump **38** receives its flow from flow mixer **37**. Flow mixer **37** has a wasp-waisted section **37***a* and communicates with lines **43** and **111**. Line **111** is the lower portion of line **44** after its junction with line **112**. The saline solution in line **111** will be a combination of weak solution withdrawn in the controlled flow line **44** and the strong solution leaving heat exchanger **11**. The saline solution of line **111** will be induced into flow-mixer **37** by the action of

the weak solution leaving line 43 through nozzle 43*a*. On passing wasp-waisted section 37*a* the solution from lines 43 and 111 will be mixed prior to entering suction inlet 57. Upon discharge from outlet 58, the solution mixture is returned through line 39 to header 19 in the absorber section to be sprayed against tube bundle 18 as described hereinbefore.

On the refrigerant side of pump unit 14, pump 28 is connected at suction inlet 72 through line 27 to evaporator sump 26. The discharge 73 of pump 28 is connected to a pair of lines. One line 82 carries a stream of refrigerant to spray header 24 for contacting evaporator tube bundle 13. A flange or similar connection 83 provides a branch from conduit 82 having a filter means 84 for carrying a minor stream of liquid refrigerant to line 87 and to the motor casing for purposes more fully described hereinafter.

Referring again to FIGURE 2 end plate 52 is provided with a radial passage 85 extending therethrough and having a threaded coupling 86 at the inlet end to which conduit 87 is communicated for passing refrigerant liquid to the interior of the motor casing.

The drive motor is preferably of the canned type including a wound stator member 47 carried against the inner peripheral wall of casing 51.

Stator 47 may be imbedded in a resin or potting compound and will be enclosed by an elongated sleeve 48 normally formed of stainless steel or the like which sleeve 48 is so positioned at flange 52 and 53 so as to define a liquid tight barrier separating stator 47 from the motor central chamber. Rotor 88 is mounted on shaft 89 and defines a slight annular gap 91 about the rotor outer surface adjacent the wall of sleeve 48.

The minor flow of refrigerant is introduced through conduits 87 and passage 85 to the motor interior. Pressure differential across the motor will urge liquid refrigerant through annular gap 91 thereby contacting and cooling adjacent walls defined by said gap and discharging refrigerant into the opposed end of the casing interior. Passage means 92 in end flange 53 extends radially therethrough and defines an outlet for liquid refrigerant from the motor casing. Passage 92 is communicated through line 94 to line 27 to pump suction inlet 72. Of course, line 94 could have been communicated with the evaporator by another line (not shown) for returning refrigerant directly to the evaporator.

Under normal operating conditions, as illustrated in FIGURES 1 and 2, water acting as refrigerant and lubricant is continuously cycled from sump 26 to evaporator spray header 24 through pump 28. Thus, so long as the system is in operation, a flow of refrigerant acting as a coolant medium is passed through line 83, filter 84, line 87, and passage 85 to be introduced to motor inner parts. Simultaneously, solution passed from absorber sump 17 and lines 43, 44, 111, and 112 is continuously cycled through pump 38 and returned by way of line 39 to absorber spray header 19.

Under ideal operating conditions, liquid seal means such as seal 67 forms a close fit between adjacent parts, and functions to prevent substantial passage of liquid between pump 38 and the drive motor compartment.

It is appreciated however that when the above described operating conditions are not obtained due to the particular seal not forming an absolutely tight wall that there is the possibility of some saline solution leaking into the motor compartment. If this were to happen, upon contacting the motor surfaces, the solution will tend to form the metallic plated layer which, if permitted, would gradually increase in thickness until damage to the motor is imminent.

This problem is avoided by exposing the saline pump side of seal 67 to a lower pressure than the pressure of the refrigerant in the motor compartment. Accordingly any flow across seal 67 will be in the direction away from the motor 88 and its motor compartment so that any leakage will be refrigerant entering in the pump 38.

Furthermore, in assuring a positive pressure on the motor side of the seal 67, means may be deposed in the downstream side of the motor compartment carrying refrigerant therefrom to throttle or limit the flow of refrigerant passing through said motor compartment. Thus, such pressure building means may include a valve, an orifice in the line, or a similar construction either fixed or variable to sufficiently sustain a positive pressure on the motor side of the seal 67 as compared with the solution side.

When the absorption system is shut down or discontinued for an extended period of time there will always be refrigerant accumulated in motor casing 51. At ambient temperatures, solution accumulated within pump 38 has a tendency to crystallize and this tendency is countered by the diluent action caused by the pressure gradient of the refrigerant which may leak through seal 67.

In another embodiment of the invention as shown in FIGURE 3, the multipump arrangement is similar to the arrangement of FIGURES 1 and 2, with a notable exception that the entire unit is disposed substantially vertically. When so positioned, and pumps 28 and 38 are inactive, there will be a gravity flow of refrigerant downward through seal 67 and into pump 38 to either dilute or gradually replace saline solution held in the latter.

Again referring to FIGURES 1 and 3, a positive refrigerent pressure is held on pump 38 even though the fluid system is entirely static. However, with the absorption system inoperative, solution will flow upwardly in line 111 and 112, as indicated by the dotted arrows, passing into heat exchanger 11 and through opening 113 and duct 114 into generator 9. Simultaneously, refrigerant from evaporator sump 26 will gravitate to pump 28 until the liquid column in line 27 is balanced with the liquid column in line 82.

The system thus will seek a point of equilibrium condition in which refrigerant and saline solution pressures are balanced, generally inversely proportioned to their respective densities. The height of refrigerants in lines 27 and 82 will then be substantially greater than the column of saline solution which has formed in the lines 39, 43, 44, 111 and 112 and in heat exchanger 11 and generator 9, thereby establishing a pressure differential across seal 67. However, since the greater pressure acts on the motor side of the seal 67, any leakage of liquid across the seal will be that of refrigerant passing in the direction toward pump 38.

For convenience, FIGURE 3 has been divided so that the indicated levels on the right side are that of refrigerant and that on the left side are that of saline solution.

Thus an arrangement similar to that shown in FIGURE 3 may dispose the refrigerant pump beneath the solution pump. In this instance flow will still be into the solution pump which is under a lesser pressure head.

Under static conditions over a period of time, solution in pump 38 will become more dilute because of refrigerant leakage but will not tend to crystallize. In contrast, such gradual mixing of solution and refrigerant will have no detrimental effect whatsoever on the purity of the solution in pump 38, but may tend to dilute the solution somewhat.

It is possible that under equilibrium conditions some solution will diffuse into the refrigerant side of the seal 67, this minute amount however is relatively negligible and of insufficient quantity to cause plating within the motor compartment.

Thus, the system will conclusively prevent the saline solution, during both operation and shut down, from entering the motor chamber of the motor pump unit 14.

Referring to FIGURE 3, it is noted that while the embodiment of the invention discloses the motor intermediate the refrigerant and solution carrying pumps 38 and 28, a similar result can be obtained with the pumps positioned vertically adjacent one to the other, with the drive motor disposed in the upper end thereof, as shown

in FIGURE 4. When so arranged, motor **102** is preferably mounted vertically with the mutually coupled pumps **101** and **103** such that the upper refrigerant carrying pump is connected directly to the solution circulating lower pump **103**; the latter being at the lowermost part of the system. The coolant refrigerant is circulated through lines **108** and **110** for return to line **27** whereby it may be returned to the suction end of pump **101**.

The present arrangement is directed primarily toward cooling of motor parts. Although no specific mention thereof is made, it is understood that the passage of refrigerant lubricant through the motor compartment serves to cool and lubricate bearings **68** and **78** which are adapted to pass liquid therethrough.

It will be understood that various changes in the details, materials, arrangement of parts and operating conditions which have been herein described and illustrated may be made by those skilled in the art within the principles and scope of the invention as expressed in the claims.

What is claimed is:

1. An absorption refrigerant system comprising:
(a) an absorber,
(b) an evaporator,
(c) a generator,
(d) a condenser,
(e) a first conduit loop means to circulate the saline solution in varying concentration between the absorber and the generator,
(f) a second conduit loop means to circulate the refrigerant in the evaporator,
(g) a saline pump disposed in the first conduit loop means and having an inlet and discharge therein,
(h) a refrigerant pump disposed in the second conduit loop means and having an inlet and discharge therein,
(i) a motor having at least one shaft connected to and driving the saline pump and the refrigerant pump,
(j) a casing housing the saline pump, the refrigerant pump, and the motor therein,
(k) a coolant conduit connected to the discharge of the refrigerant pump to circulate refrigerant to cool the motor.
(l) a seal means disposed on the shaft having one side adjacent the saline pump and exposed to the inlet suction pressure thereof, and the other side of the seal exposed to the refrigerant at the refrigerant pump discharge pressure to cause leakage through the seal in the direction of the saline pump.

2. The combination claimed in claim **1** wherein:
(a) the motor disposed between the saline pump and the refrigerant pump and having a shaft extending into and driving said pumps,
(b) the last mentioned seal means disposed on the shaft between the saline pump and the motor to permit leakage of the refrigerant at discharge pressure across the seal in the direction of the saline pump.

3. The combination claimed in claim **2** wherein:
(a) a second seal means disposed on the shaft between the motor and the refrigerant pump,
(b) the second seal means having the side thereof adjacent the refrigerant pump exposed to the discharge pressure thereof whereby any leakage through the seal will be in the direction of the motor to permit complete cooling of the motor.

4. An absorption refrigeration system for circulating a saline solution which includes a hydrophylic salt and a refrigerant comprising:
(a) an absorber,
(b) an evaporator,
(c) a generator disposed below the absorber and evaporator,
(d) a condenser,
(e) a saline pump,
(f) a refrigerant pump,
(g) a motor connected to drive the saline pump and the refrigerant pump,
(h) a saline distribution means, including the saline pump, to circulate the saline solution in varying concentration during operations of said system between the absorber and the generator, and during periods of non-operation of said system to permit the saline solution to collect in the generator,
(i) a refrigerant distribution means, including the refrigerant pump, to pass refrigerant from the condenser and to circulate the refrigerant in the evaporator during operation of said system, and during periods of non-operation of said system to initially collect refrigerant in the evaporator prior to its passing into and collecting in the refrigerant distribution means at an elevation higher than the elevation of the collected saline solution in the generator,
(j) a seal means having the saline pump on one side thereof and the refrigerant and the motor on the other side thereof, and at all times to permit the refrigerant at higher pressure to leak across the seal means in the direction of the saline pump.

5. The combination claimed in claim **4** wherein:
(a) a casing housing the saline pump, the refrigerant pump and the motor,
(b) a shaft extending from the motor to drive the saline pump and the refrigeration pump,
(c) the seal means disposed on the shaft, and at an elevation below the generator.

6. The combination claimed in claim **5** wherein:
(a) the casing disposed below the generator.

7. An absorption refrigeration system for circulating a saline solution and a refrigerant in varying concentrations therein comprising:
(a) an absorber for decreasing the concentration of the saline solution,
(b) an evaporator for passing vaporous refrigerant to the absorber,
(c) a generator for concentrating the saline solution by driving off refrigerant therefrom,
(d) the generator disposed below the absorber and the evaporator,
(e) a condenser for receiving vaporous refrigerant from the generator and liquefying the refrigerant prior to passing it to the evaporator,
(f) a casing,
(g) a motor having a shaft extending into the casing,
(h) a seal means in said casing about the shaft to divide the casing into a saline portion and a refrigerant portion,
(i) a saline pump in the saline portion of the casing connected to the shaft and rotated by the motor and having an inlet and discharge thereon,
(j) a refrigerant pump in the refrigerant portion of the casing connected to the shaft and rotated by the motor and having an inlet and a discharge thereon,
(k) a first conduit connected to the discharge of the saline pump to normally circulate the saline solution in the varying concentrations between the absorber and the generator and during periods of non-operation of the system to permit the saline solution to collect in the generator,
(l) a second conduit connected to the discharge of the refrigerant pump to normally circulate refrigerant in the evaporator, and during periods of non-operation of said system to initially collect refrigerant in the evaporator prior to passing the refrigerant into the second conduit means wherein it will collect at an elevation higher than the elevation of the collected saline solution in the generator, and
(m) the seal means in the casing having the side adjacent the saline portion thereof subject to the suction pressure of the saline pump and the side adjacent the refrigerant portion subject to the discharge

pressure of the refrigerant pump whereby the refrigerant at the higher discharge pressure of the refigerant pump will at all times leak across the seal in the direction of the saline portion of the casing.

8. The combination claimed in claim 7 wherein:

(a) the motor disposed between the saline pump and the refrigerant pump,

(b) a third conduit means communicating refrigerant at discharge pressure to normally cool the motor, and during periods of non-operation of the system to expose the seal means to the higher pressure of the refrigerant to prevent the saline solution from leaking across the seal into the motor.

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