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[45] **May 22, 1973**

[54] **ROTARY PUMP FOR HEATING AND COOLING SYSTEM**

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[73] Assignee: **Carrier Corporation**, Syracuse, N.Y.

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[52] **U.S. Cl.** **415/88**

[51] **Int. Cl.** **F04d 1/12**, F04b 35/04

[58] **Field of Search** 415/88, 89; 417/420; 310/104

[56] **References Cited**

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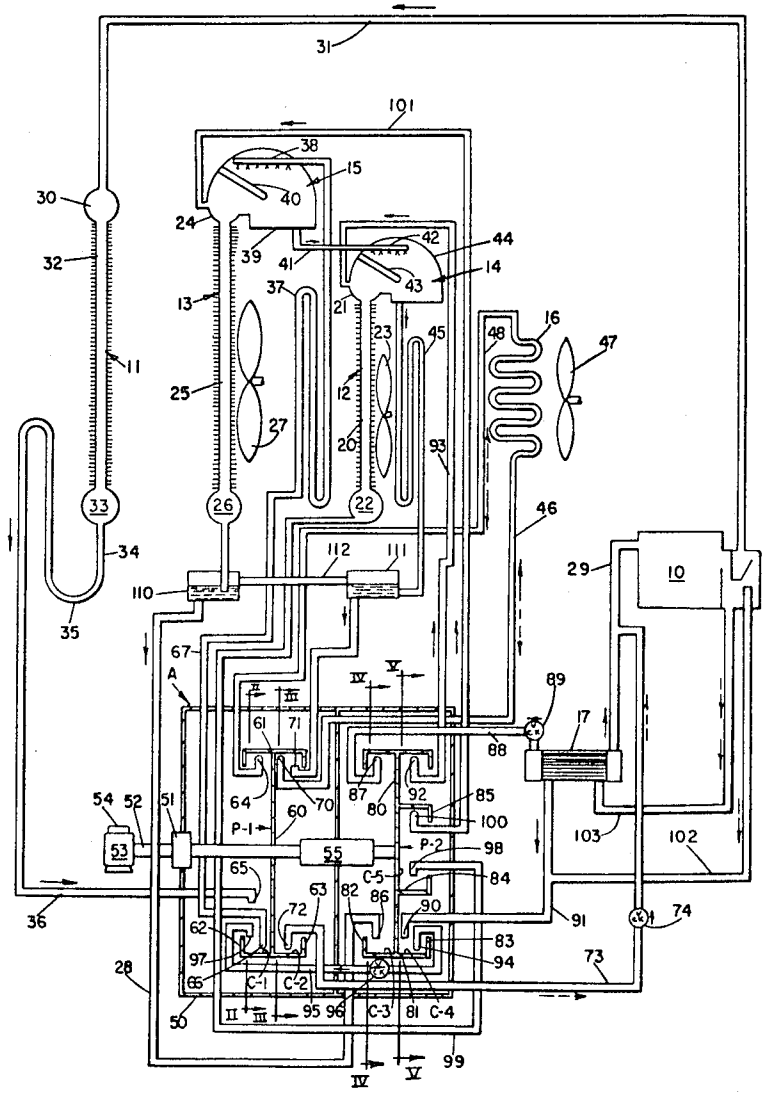
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Assistant Examiner—John T. Winburn
Attorney—Harry G. Martin and J. Raymond Curtin

[57] **ABSTRACT**

An absorption refrigeration system having a cooling and a heating mode of operation. A generator, an air-cooled condenser, a two-stage air-cooled absorber, a two-stage adiabatic evaporator and an air conditioning heat exchanger are connected to provide cooling. A heating mode of operation is provided wherein absorbent solution is heated in the generator and passed through the heat exchanger back to the generator to supply heat to a space being conditioned. The system embodies a plural trough solution scoop pump and a plural trough refrigerant or chilled water scoop pump mounted on a single shaft and driven by a single reversible motor to effect a change from cooling to heating and return.

3 Claims, 5 Drawing Figures



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SHEET 1 OF 2

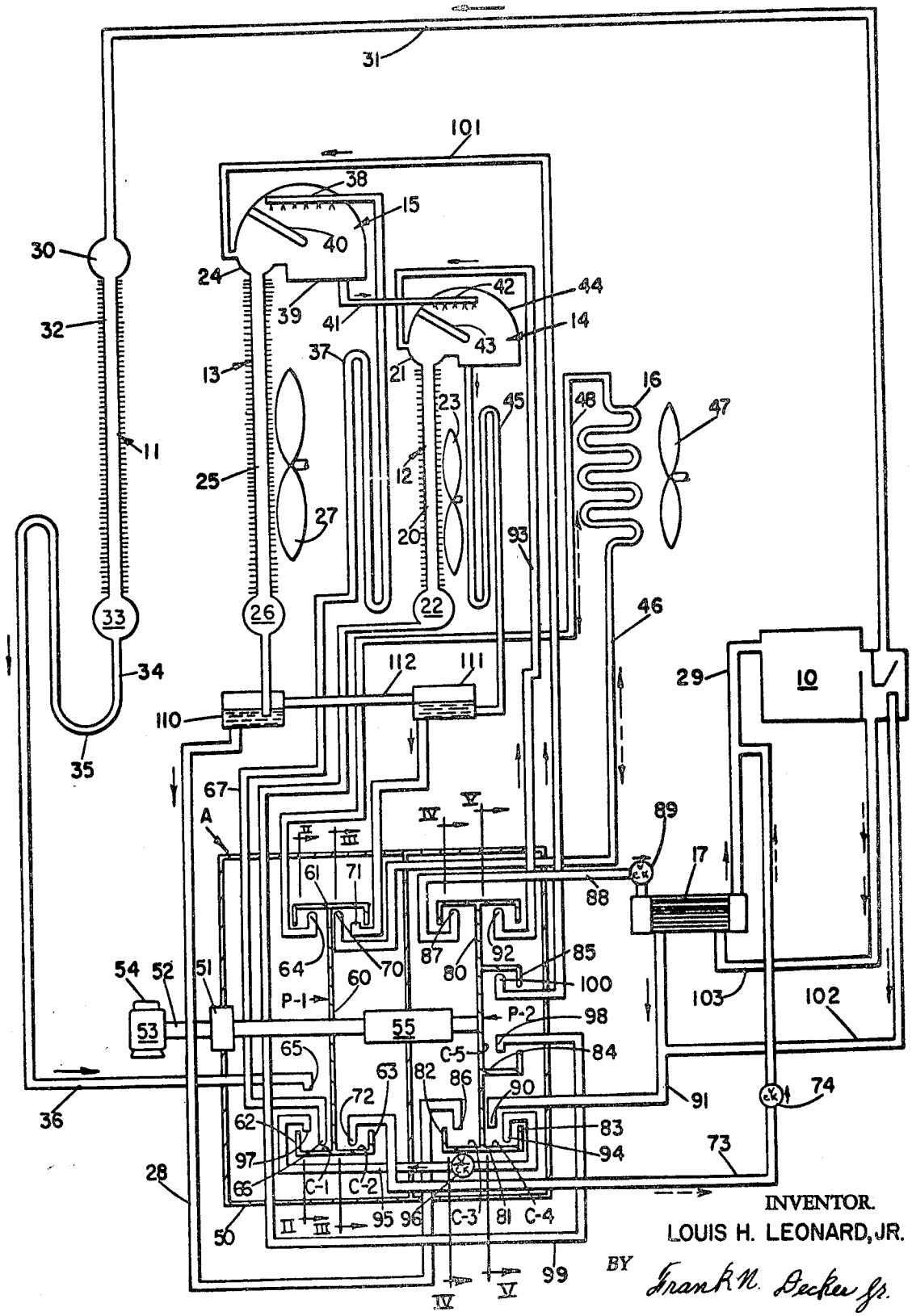


FIG. 1

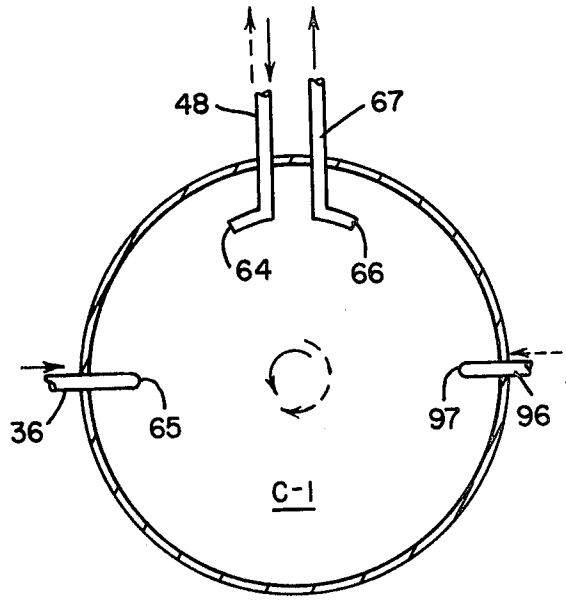


FIG. 2

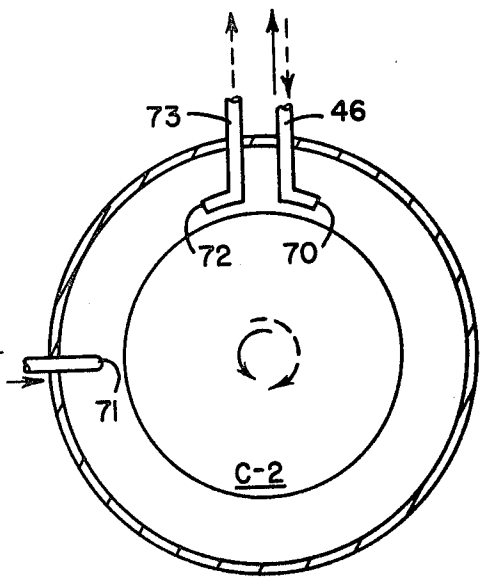


FIG. 3

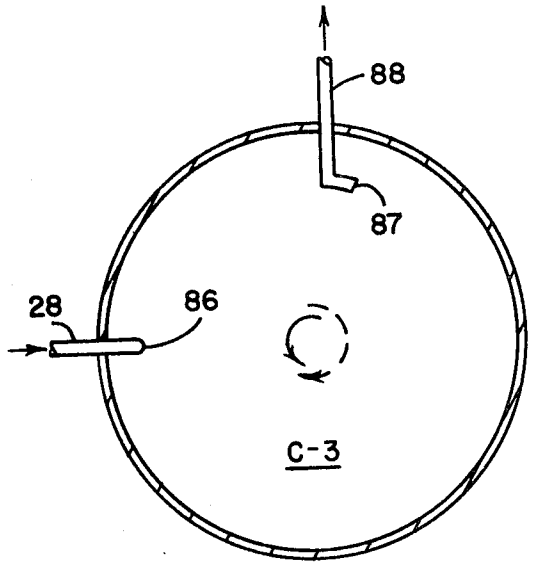


FIG. 4

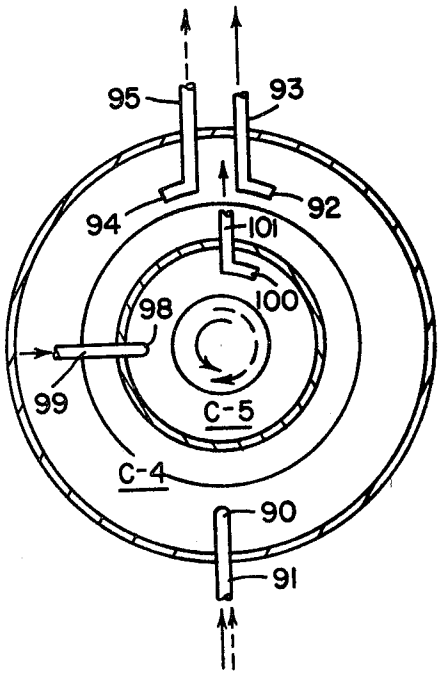


FIG. 5

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ROTARY PUMP FOR HEATING AND COOLING SYSTEM

This application is a division of application Ser. No. 20,772, filed Mar. 18, 1970 now U.S. Pat. No. 3,608,628.

BACKGROUND OF THE INVENTION

This invention relates to absorption systems which are capable of providing either refrigeration or heating. It is known to employ centrifugal pumps to pump strong absorbent solution to the absorber, weak absorbent solution to the generator, and refrigerant to the evaporator. Centrifugal pumps require that a positive head exist in order to force the liquid into the impeller eye without flashing and vapor binding and this head requirement adds complexity and height to the absorption machine and limits the application thereto of centrifugal pumps.

A heating and cooling absorption system has been proposed which utilizes one or more control valves, generally of the hermetic motorized or solenoid type, to divert both the refrigerant and absorbent solution into the generator where the mixture is heated and passed to a suitable heat exchanger, when heating is desired. Such valves are relatively expensive and not totally reliable, and accordingly, it would be desirable if this type valve could be completely eliminated from the system.

SUMMARY OF THE INVENTION

A absorption machine is provided having a cooling cycle comprising a generator, a condenser, an absorber, an evaporator, and a heat absorbing heat exchanger. The refrigerant is cooled in the evaporator and passed in heat exchange relation with the region to be cooled by means of the heat absorbing heat exchanger. On the heating mode of operation, the passage of fluid through the system is rearranged so that the absorbent solution is mixed with the refrigerant and heated in the generator. The heated mixture is circulated through a suitable heat rejecting heat exchanger to provide heat to a desired region and is returned to the generator for reheating. Preferably, the heat absorbing heat exchanger of the cooling mode is the same as the heat rejecting heat exchanger of the heating mode.

In accordance with this invention, there is also provided in the absorption refrigeration system, fluid transfer apparatus for circulating absorbent solution and refrigerant through the system. The fluid transfer apparatus desirably takes the form of one or more hermetic housings enclosing a solution scoop pump and a refrigerant scoop pump, the troughs being supported for rotation on a shaft driven by a reversible type motor. Driving the troughs of the scoop pumps in one direction causes solution and refrigerant to circulate through the system on the cooling cycle, and by simply reversing the motor, the system is automatically changed over to the heating cycle with the troughs rotating in the reverse direction. In this manner, the use of centrifugal pumps and control valves for switching between cooling and heating operation are avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic flow diagram, partially in cross section, of a heating and cooling system in accordance with this invention;

FIG. 2 is a cross section through a heating and cooling system taken substantially along line II—II of FIG. 1;

FIG. 3 is a cross section through a heating and cooling system taken substantially along line III—III of FIG. 1;

FIG. 4 is a cross section through a heating and cooling system taken substantially along line IV—IV of FIG. 1; and

FIG. 5 is a cross section through a heating and cooling system taken substantially along line V—V of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

This invention will be described with respect to a preferred embodiment wherein a two-stage adiabatic refrigerant evaporator and a two-stage air-cooled absorber are employed in the cooling mode of operation. However, this invention may be employed in systems having any number of either adiabatic or nonadiabatic evaporator stages.

The preferred refrigerant is water and the preferred absorbent is an aqueous solution of lithium bromide, although other absorbent-refrigerant combinations, especially those including a lithium halide salt, may be employed instead. As used herein, a concentrated solution of lithium bromide which is strong in absorbing power will be referred to as "strong solution". "Weak solution" is a dilute solution of lithium bromide which is weak in absorbing power. A suitable compound, such as octyl alcohol (2-ethyl-n-hexanol) may be added to the solution for heat transfer promotion and corrosion inhibitors may be used if desired.

Referring to the drawings, the system comprises a generator **10**, a condenser **11**, a low pressure absorber **12**, a high pressure absorber **13**, a low temperature adiabatic evaporator **14**, a high temperature adiabatic evaporator **15**, an air conditioning heat exchanger **16**, a solution heat exchanger **17**, and fluid transfer apparatus generally designated by the legend A. Heat exchanger **16** provides sensible heat exchange between cold liquid refrigerant and air being conditioned when the system is connected to provide refrigeration and therefore functions as a heat absorbing heat exchanger. If a nonadiabatic conventional evaporator is employed, heat exchanger **16** may be located in the evaporator.

Generator **10** may be of the known shell-and-tube type heated by a fuel burner, or in the alternative, may utilize steam or hot water as the heating fluid. Weak solution is supplied to generator **10** and boiled therein to concentrate the solution in the cooling mode of operation, the pumping being done by fluid transfer apparatus A.

Low pressure absorber **12** comprises a plurality of vertically disposed finned absorber heat exchange tubes **20** connected at their upper ends by a low pressure vapor header **21** and at their lower ends by a low pressure liquid header **22.** Strong solution overflows the open upper ends of absorber tubes **20** and passes downwardly along the inner surfaces of the absorber tubes while absorbing refrigerant vapor therein. The heat of the absorption process is rejected to ambient air passed over the exterior surfaces of absorber tubes by fan **23.** The absorbent solution is somewhat diluted by absorption of refrigerant vapor in tubes **20,** so that the solution collected in low pressure liquid header is of in-

termediate concentration and drains therefrom into fluid transfer apparatus A and is pumped to high pressure vapor header **24** of high pressure absorber **13**.

High pressure absorber **13** comprises a plurality of finned vertical absorber heat exchange tubes **25** joined at the upper ends by header **24** and at their lower ends by high pressure liquid header **26**. Intermediate absorbent solution overflows the upper open ends of absorber tubes **25** and passes downwardly along the interior surfaces of the absorber tubes while refrigerant vapor is being absorbed therein. The heat of the absorption process is rejected from high pressure absorber **13** to ambient air passed over the exterior surfaces of absorber tubes **25** by fan **27**.

Absorbent solution passing downwardly through absorber tubes **25** is further diluted by the absorption of refrigerant vapor therein so that the absorbent solution collected in high pressure liquid header **26** is weak in absorption power. The weak solution passes from liquid header **26** through drain conduit **28** into fluid transfer apparatus A from which it is pumped through the interior of the tubes of solution heat exchanger **17** and through weak solution passage **29** into generator **10** for reconcentration therein.

Refrigerant vapor is formed in generator **10** by the boiling of absorbent solution. This refrigerant vapor passes from generator **10** to refrigerant vapor header **30** of condenser **11** through refrigerant vapor conduit **31**. Refrigerant condenser **11** comprises a plurality of vertically disposed finned tubes **32** connected at their upper ends by vapor header **30** and at their lower ends by refrigerant condensate header **33**. Preferably, condenser **11** is located to receive air passing over the tubes in absorber **13** in order to utilize the absorber fans for passage of cooling air over the condenser. The refrigerant condensate formed in condenser **11** passes from header **33** through condensate passage **34** having a downwardly extending loop or trap **35** connected thereto and through condensate conduit **36** to fluid transfer apparatus A to be pumped therefrom through isolation loop **37** to high temperature adiabatic evaporator **15** through spray header **38** therein.

High temperature adiabatic evaporator **15** preferably comprises a shell **39** mounting therein a baffle member **40** for directing the vapor droplets discharged from spray header **38** into conduit **41** communicating with low temperature adiabatic evaporator **14**. A small quantity of refrigerant is evaporated from refrigerant passing through high temperature evaporator, thereby flash-cooling the remaining refrigerant. The cooled refrigerant passes from high temperature evaporator **15** to low temperature evaporator **14** through refrigerant passage **41** which has connected thereto spray header **42** for discharging liquid refrigerant against baffle member **43** disposed within shell **44** of low temperature evaporator **14**. Within evaporator shell **44** a further small quantity of refrigerant is evaporated which results in flash-cooling the remainder of refrigerant passing therethrough to a still lower temperature. In all, only about 1 percent of the total refrigerant flowing through adiabatic evaporators **14** and **15** need be evaporated to satisfactorily flash-cool the remaining 99 percent. It is preferred to employ adiabatic evaporators in which the refrigerant is flash-cooled and no external heat is added; however, conventional single or multi-stage evaporators having heat absorbing heat exchangers therein may be employed, if desired.

The cold refrigerant then passes from low temperature evaporator **14** through an isolation loop **45** and drains into fluid transfer apparatus A from which it is pumped through conduit means **46** up through heat absorbing heat exchanger **16** having in association therewith fan means **47** for passing air to be conditioned over the heat exchanger. Heat exchanger **16** passes cold liquid refrigerant in heat exchange relation with the air passing thereover to cool the air which constitutes a refrigeration load in the cooling mode of operation. After absorbing heat from the air being cooled, the warmed liquid refrigerant drains down through conduit means **48** connected to heat exchanger **16** and into fluid transfer apparatus A from which it is pumped through isolation loop **37** back to the high temperature evaporator.

Prior to describing the heating mode of operation, the fluid transfer apparatus A will be described. The apparatus A may comprise a hermetic housing **50** mounting hermetic magnetic drive means **51** connected at one end by shaft means **52** to a single reversible motor **53** equipped with either a manual or automatic switching means **54**. The shaft means **52** at the opposite end of the magnetic drive means **51** is journaled in solution lubricated radial and thrust bearing means **55** and supports on opposite sides of the bearing means a double-trough chilled water scoop pump P-1 and a triple-trough solution scoop pump P-2.

The pump P-1 includes a central partition member **60** supported by the drive shaft **52**, the partition having connected thereto along its circumference an annular wall member **61** having radially inwardly directed wall portions **62** and **63** to define with the partition member **60** a pair of refrigerant circulation chambers C-1 and C-2. Leading into chamber C-1 is inlet passage portion **64** forming a part of conduit **48** connected to air conditioning heat exchanger **16**. Passage **64** functions as a drain line when the system is on the cooling mode of operation and as a pump inlet passage when the system is on the heating cycle. An inlet orifice **65** of conduit **36** passes refrigerant from the condenser header **33** to chamber C-1. Eduction orifice **66** of conduit **67** passes liquid refrigerant from chamber C-1 to high temperature evaporator **15** through circulation loop **37**.

Chamber C-2 has therein a passage **70** forming a part of conduit means **46** leading to air conditioning heat exchanger **16** and which conduit portion performs a dual function. Passage **70** carries cool refrigerant pumped to the heat exchanger **16** when the system is on the cooling mode of operation and performs a drain function when on the heating cycle. Also in chamber C-2 is conduit portion **71** leading through sump **111** and circulation loop **45** to low temperature evaporator **14** to drain cold liquid refrigerant into this chamber. There is also in chamber C-2 conduit portion or eduction orifice **72** of conduit means **73** for transferring refrigerant through check valve means **74** to the generator **10** when the system is providing heating.

Scoop pump P-2 comprises a central partition member **80** secured to drive shaft **52** and mounting along its circumference an annular wall member **81** provided with radially inwardly directed wall portions **82** and **83** to define a pair of solution circulation chambers C-3 and C-4. Also attached to the partition member **80** is an annular wall member **84** circumferentially inwardly spaced from wall member **81** and having attached thereto a radially inwardly extending annular wall por-

tion 85 defining with partition 80 and wall member 84 a solution circulation chamber C-5.

Solution circulation chamber C-3 has leading thereto conduit portion 86 of conduit means 28 for transferring into this chamber weak solution draining from high pressure liquid header 26 of high pressure absorber 13. The weak solution is pumped from chamber C-3 by scoop 87 of conduit means 88 and passed through check valve 89, solution heat exchanger 17 and weak solution passage 29 into generator 10 for reconcentration therein.

Solution circulation chamber C-4 has three conduit portions leading thereto. The first conduit 90 is a double function drain line forming a part of conduit means 91 communicating with solution heat exchanger 17 and conveying strong solution from generator 10 to chamber C-4, from which it is pumped by eduction orifice 92 of conduit means 93 and transferred thereby to low pressure absorber 12. The dual function line 90 drains solution into chamber C-4 on both the cooling and heating modes of operation. On the heating cycle, solution is also pumped from chamber C-4 by eduction orifice 94 of conduit means 95 and transfered through check valve 96 and drain conduit portion 97 into chamber C-1 from which it is pumped to air conditioning heat exchanger 16 by means of eduction orifice 64 of conduit means 48. The conduit means 95 and associated eduction orifice 94 and drain conduit portion 97 are inactive when the system is on the cooling cycle as will be subsequently explained.

Solution circulation chamber C-5 has leading thereto drain conduit portion 98 of conduit means 99 communicating with low pressure liquid header 22 of low pressure absorber 12 for transferring to chamber C-5 intermediate solution which is pumped therefrom by eduction orifice 100 of conduit means 101 and passed to high pressure absorber 13.

Generator 10 has connected thereto a solution bypass conduit 102 through which approximately 80 percent of the solution flows to conduit 91 when the system is on the heating mode of operation, the remaining solution on the heating cycle passing through conduit 103 which passes all of the fluid when the system is on the cooling mode of operation.

As will be seen from FIG. 2, eduction orifice 64 of passage 48 faces in a counterclockwise direction in chamber C-1 and eduction orifice 66 of passage 67 faces in a clockwise direction in the chamber. Consequently, rotation of the scoop pump pan in a counterclockwise direction causes liquid to be impelled into eduction orifice 66 while orifice 64 merely trails in the wake of the preceding scoop. Similarly, when the scoop pump is rotated in a clockwise direction, eduction orifice 66 merely trails in the wake of the passage 48 containg eduction orifice 64 into which liquid is impelled. In FIG. 3, eduction orifices 70 and 72 face in a counterclockwise and clockwise direction respectively and are consequently only operative in the correspondingly opposite direction of rotation of pan or chamber C-2 which is axially spaced from pan or chamber C-1.

As shown in FIG. 4, solution chamber C-3 is arranged with eduction orifice 87 facing in a clockwise direction in order that counterclockwise rotation of the pan causes liquid to be impelled into the chamber, whereas the opposite rotation does not result in pumping.

FIG. 5 illustrates a cross section through the concentric pans forming scoop pumps C-4 and C-5. Eduction orifices 92 and 94 face in a clockwise and a counterclockwise direction respectively, to receive liquid therein only when the pan is rotated in a correspondingly opposite direction. In both instances, liquid is supplied by drain line 91 through orifice 90 which is preferably disposed approximately 180° removed from scoops 92 and 94 to provide a maximum resistance time for the liquid in the pan so that it will be accelerated to a relatively high velocity before reaching the scoop. Intermediate solution chamber C-5 contains only a clockwise facing eduction orifice 100 operative only on counterclockwise rotation of the pan to receive liquid. It is preferred to locate inlet orifice 98 of passage 99 greater than 180° from the eduction orifice to permit for acceleration of the liquid to its maximum velocity before being received by the scoop.

During cooling operation of the absorption system, motor 53 is rotated in a counterclockwise direction causing scoops 66, 70, 87, 92 and 100 to be operative while scoops of eduction orifices 64, 72 and 94 do not pump liquid but trail in the wake of the preceding scoop. With motor 53 rotating in a counterclockwise direction, strong solution drains from generator 10 through passage 103, heat exchanger 17 and strong solution passage 91 into strong solution chamber C-4. The strong solution is picked up by eduction orifice 92 and pumped through passage 93 to vapor header 21 of low pressure absorber stage 12. The strong solution passes downwardly through the absorber tubes 20, absorbing refrigerant vapor, which dilutes the strong solution. The intermediate strength solution is collected in liquid header 22. The intermediate solution passes through solution passage 99 and drains through inlet orifice 98 into chamber C-5. The rotation of scoop pump pan forming chamber C-5 causes the intermediate solution to be picked up by eduction orifice 100 and pumped through passage 101 to vapor header 84 of high pressure absorber stage 13. The absorbent solution passes downwardly through absorber tubes 25 and is further diluted by absorption of refrigerant vapor. Weak solution is collected in liquid header 26 and passes through weak solution passage 28 from which it drains through orifice 86 into weak solution chamber C-3. The weak solution is picked up by eduction orifice 87 and pumped through weak solution passage 88, heat exchanger 17, and weak solution passage 29 to generator 10 for reconcentration therein.

The refrigerant vapor formed by generator 10 passes through vapor passage 31 to condenser 11 where it is condensed by heat exchange with ambient air. The refrigerant condensate is collected in condensate header 33, passes through passage 34, isolation loop 35 and condensate passage 36 from which it drains into chamber C-1 through orifice 65. Rotation of the pan forming chamber C-1 in the counterclockwise direction causes the liquid refrigerant to be picked up by scoop 66 and passed through passage 67, isolation loop 37 and spray header 38 into high temperature evaporator 15. The refrigerant is flash-cooled in the high temperature evaporator and the cool remaining liquid drains through passage 41 and spray header 42 into low temperature evaporator 14. The liquid refrigerant is further flash-cooled in the low temperature evaporator and the cold remaining refrigerant passes therefrom through loop 45 into sump 111. The cold refrigerant drains from sump 111 through drain orifice 71 into

chamber C-2. The cold liquid is picked up by eduction orifice 70.

In accordance with this invention, the system is switched from cooling to heating mode operation by simply reversing the direction of motor 53 so that it rotates in a clockwise direction. When the scoop pump pans rotate in a clockwise direction, scoops 64, 72 and 94 are operative to pump liquid, and scoops 66, 70, 87, 92 and 100 do not have liquid impelled into them. Warm solution from generator 10 continues to pass through passage 103, heat exchanger 17, and passage 91 from which it drains through orifice 90 into solution chamber C-4. The hot solution is then picked up by orifice 94 and passed through passage 95 and transferred through check valve 96 to chamber C-1 into which it drains from orifice 97. The hot solution discharged into chamber C-1 is picked up by orifice 64 and passes through passage 48 into air conditioning heat exchanger 16 to provide heating to the desired location. The solution is then returned through passage 46 having orifice 70 therein to chamber C-2. This solution is impelled into orifice 72 of passage 73 through which it is pumped past check valve 74 into generator 10 for reheating.

It will be noted that the hot solution is substantially diluted by having been mixed with refrigerant in its passage through chambers C-1 and C-2, so that it forms a solution having a relatively low freezing point. In addition, the volume of solution being circulated to the generator is increased by being mixed with the refrigerant in the system so that the level in the generator will rise and overflow the top of passage 102. Thus, hot solution will continue to be supplied from the generator into chamber C-4 through both passages 103 and 102 while the system is operating in the heating mode.

When it is desired to return the system from the heating mode to the cooling mode of operation, the direction of motor 53 is again reversed, so as to drive the scoop pump pans in a counterclockwise direction. While the direction of liquid flow in the system will be the same as previously described for cooling operation, it will be apparent that the mixture of refrigerant and absorbent solution must be separated to provide full cooling capacity. This is achieved by providing a refrigerant sump 111 in refrigerant passage 45 and an absorbent sump 110 in solution passage 28 with an overflow passage 112 extending between the two sumps. As long as the volume of refrigerant evaporated is low, due to having substantial absorbent mixed therein, the level of refrigerant in sump 111 will be relatively high. Consequently, liquid will drain from sump 111 through passage 112 into sump 110 from which it will pass through chamber C-5 to generator 10 where refrigerant will be separated therefrom. The bleeding of refrigerant to the generator through passage 112 will continue until the refrigerant has become sufficiently purified to sustain the refrigeration load on the system, thereby providing the desired refrigeration capacity.

The invention described herein utilizes the unique and special properties of a scoop pump to effectively pump liquid in an absorption refrigeration system in the absence of a suction head and in the presence of noncondensable gases or other vapors without injurious effect to the pump. Furthermore, by utilizing scoops or eduction orifices facing different directions in the pump, it is possible to switch the fluid flows in the system to provide either heating or cooling without the use of expensive reversing valves by simply reversing the direction of rotation of the scoop pump pans. Accordingly, there is provided an improved absorption system and a scoop pump capable of operating as both a pump and a valve for supplying liquid to one or more selectable locations depending on the direction of rotation of the pump.

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

I claim:

1. A combined pump and valve apparatus for controlling the flow of liquid in a system, said apparatus comprising a housing, a rotatable pan mounted for rotation therein, a reversable electric motor including means to reverse the direction of rotation of said electric motor, said electric motor being connected to rotate said pan in a direction corresponding with the direction of rotation of the motor; a first stationary scoop extending into said pan having an eduction orifice facing in one direction of rotation of said pan; a second stationary scoop extending into said pan having an eduction orifice facing opposite said one direction of rotation of said pan; a stationary discharge conduit extending toward said pan and being positioned for discharging liquid therein; and means for actuating said electric motor to run in said one direction of rotation when liquid flow through said second scoop is desired and to actuate said electric motor to run in the other direction when liquid flow through said first scoop is desired, whereby liquid from said discharge conduit is selectively pumped into either said first or said second scoop depending on the selected direction of rotation of said reversable electric motor.

2. A combined pump and valve assembly as defined in claim 1 wherein said scoop pump pan is axially divided into a plurality of scoop pump pans, each having a scoop and an inlet passage for pumping a plurality of liquid streams.

3. A combined pump and valve assembly as defined in claim 1 wherein said scoop pump pan is divided into a plurality of concentric scoop pump pans, each having a scoop and an inlet passage for pumping a plurality of liquid streams.

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