Sept. 28, 1971 L. H. LEONARD, JR 3,608,332

ABSORPTION REFRIGERATION SYSTEM

Filed March 18, 1970 32 Sheets-Sheet 1

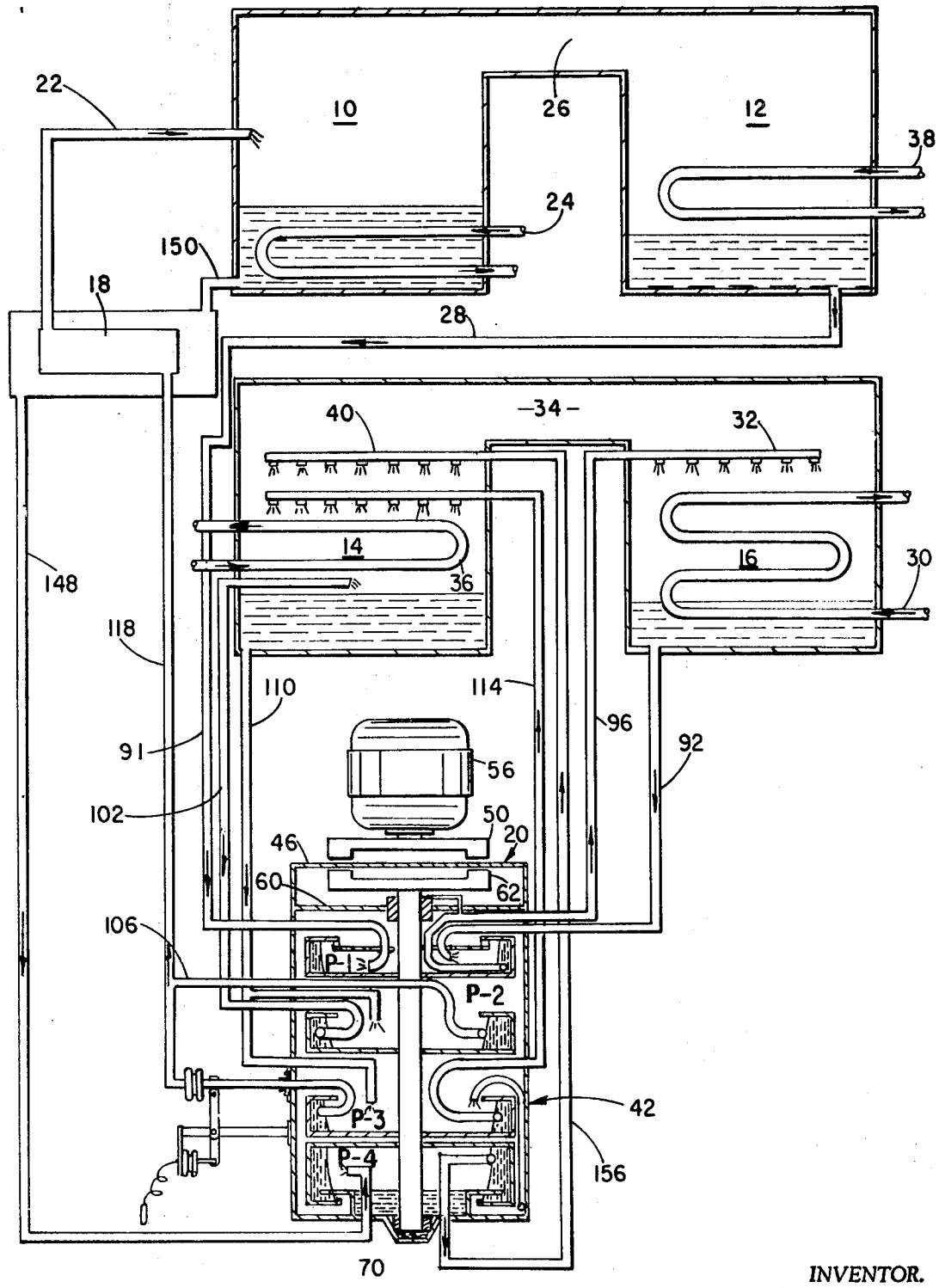

FIG. 1

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ABSORPTION REFRIGERATION SYSTEM

Filed March 18, 1970 2 Sheets-Sheet 2

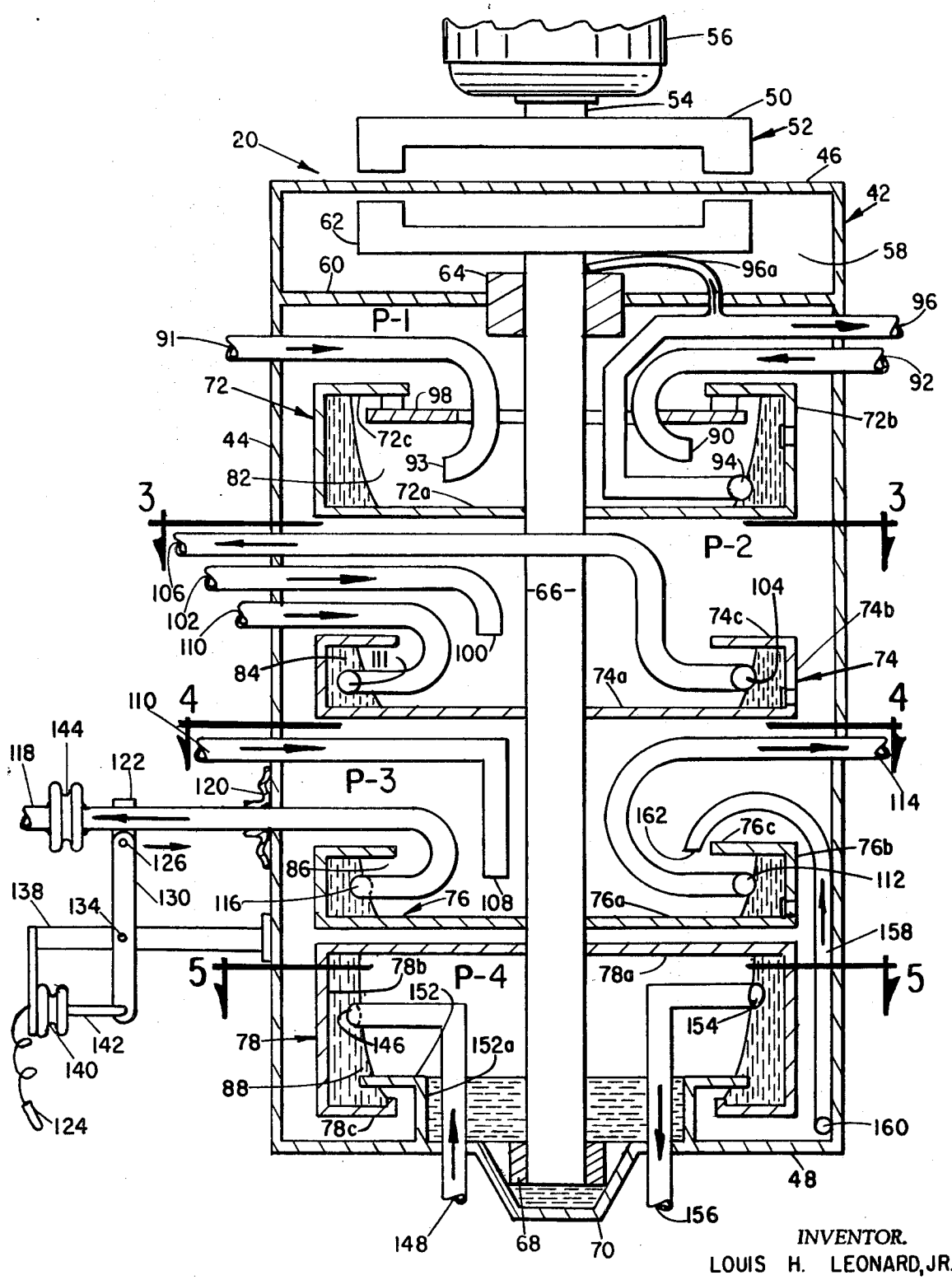

FIG. 2

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ABSORPTION REFRIGERATION SYSTEM

Filed March 18, 1970 3 Sheets-Sheet 3

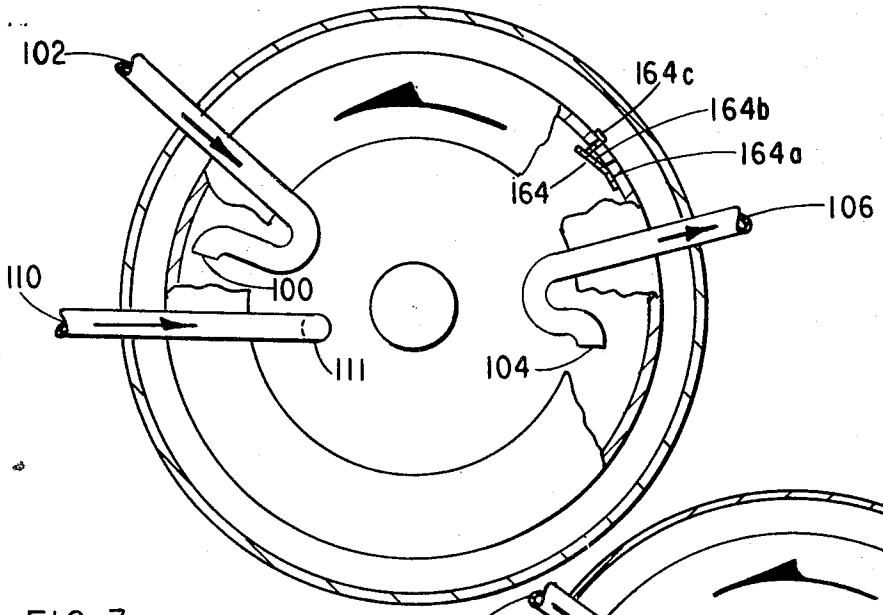

FIG. 3

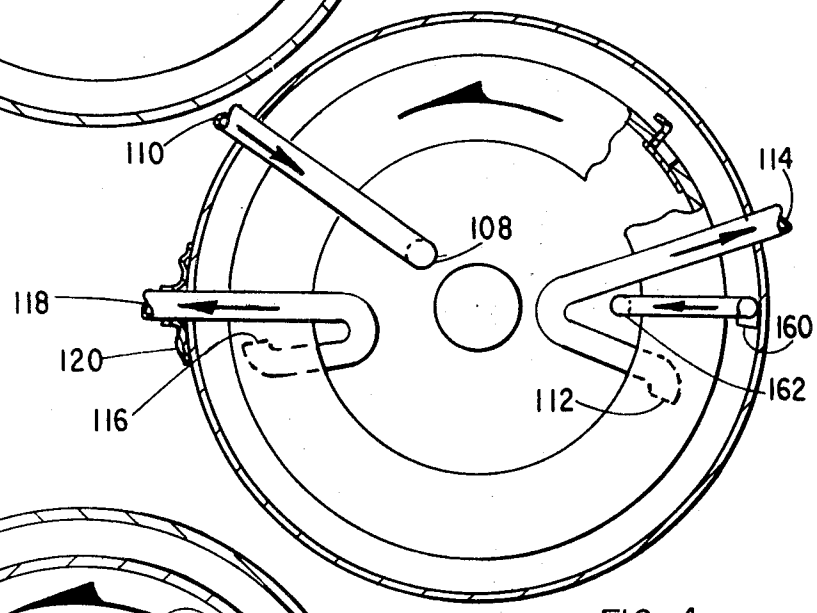

FIG. 4

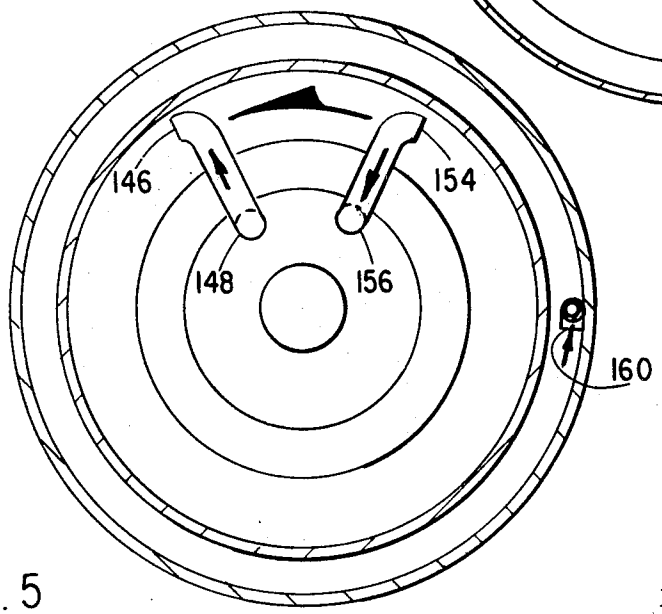

FIG. 5

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3,608,332

ABSORPTION REFRIGERATION SYSTEM

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Int. Cl. F25b 15/06
U.S. Cl. 62—476 5 Claims

ABSTRACT OF THE DISCLOSURE

An absorption refrigeration system wherein there is provided in communication with the evaporator, absorber, generator and condenser fluid handling apparatus in the form of a hermetic housing mounting therein a rotatively driven shaft member journaled at opposite ends in bearing means and supporting a plurality of scoop pumps for effecting, among other functions, circulation of refrigerant and absorbent solution through the system, purging, and machine capacity control.

BACKGROUND OF THE INVENTION

It is common to employ centrifugal pumps to circulate refrigerant and absorbent solution in an absorption refrigeration system. Centrifugal pumps require that a positive head exist on the pump inlet in order to force the liquid into the impeller eye, to prevent flashing and vapor binding in the pump. This available head at the pump intake is referred to as "net positive suction head" or "NPSH." The requirement for NPSH in centrifugal pumps necessarily adds complexity and height to the absorption machine.

It has been proposed to transfer absorbent solution to the absorber in an absorption refrigeration machine by using a scoop pump, taking the form of a closed chamber within which is rotatably mounted a peripherally flanged disc for centrifugally impelling liquid directed into the chamber through an inlet conduit, the liquid being picked up by a scoop or eduction tube. Scoop pumps have among their advantages simplicity of construction, negligible NPSH requirements and normally will not cavitate even though only a relatively small quantity of fluid is fed to them. Further, they are essentially free of the flashing and vapor binding problem which characterizes centrifugal pumps. Such prior proposals have merely substituted a conventional scoop pump for another type of conventional pump for pumping absorbent solution without fully achieving or utilizing the advantages of the scoop pump. Furthermore, the prior proposals have been unsatisfactory in absorption refrigeration systems of the lithium bromide type which operate under high vacuum because they contained seals exposed to atmosphere which could leak air into the machine and cause capacity and corrosion problems. Also, replacement of prior scoop pump motors required opening the machine to atmosphere, after which elaborate purging of air from the machine was required.

Accordingly, it is a principal feature of this invention to design an improved fluid handling apparatus, especially designed for an absorption refrigeration system, which provides features, advantages and improvements

over, and overcomes the disadvantages of, prior scoop pump proposals.

SUMMARY OF THE INVENTION

In accordance with this invention, there is provided an absorption refrigeration machine, which may be either of the air-cooled or water-cooled type, and which embodies fluid handling apparatus taking the form of a hermetic housing supporting interiorly a shaft member which may be journaled at opposite ends in solution lubricated bearing means. The shaft member is rotatively driven by an exteriorly mounted motor through a high torque magnetic coupling. Affixed to the rotatable shaft are a plurality of scoop pumps, each preferably taking the form of a pan or trough into which leads one or more fluid inlet conduits and one or more scoops or eduction conduits. The pans or annular collection containers define with the housing a plurality of chambers for flash cooling refrigerant, purging, and circulating refrigerant and solution through the system. In a preferred arrangement the shaft member is vertically disposed, the lower bearing is constantly submerged in solution for lubrication thereof, and the upper bearing is lubricated with refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic flow diagram, partially in cross-section, of an absorption refrigeration system embodying an exemplary form of fluid handling apparatus;

FIG. 2 is a side elevational view of the fluid handling apparatus of FIG. 1 somewhat enlarged to more fully illustrate certain details thereof;

FIG. 3 is a sectional view taken substantially long the line 3—3 of FIG. 2 showing a purge pump arrangement;

FIG. 4 is a sectional view taken substantially along the line 4—4 of FIG. 2 illustrating a scoop pump for transfer of relatively weak absorbent solution; and

FIG. 5 is a sectional view taken substantially along the line 5—5 of FIG. 2 showing a scoop pump for handling relatively strong absorbent solution.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with a preferred embodiment of this invention, there is provided an absorption refrigeration system which utilizes water as a refrigerant and an aqueous solution of lithium bromide as an absorbent. A suitable compound, such as octyl alcohol (2-ethyl-n-hexanol), may be added to the solution for heat transfer promotion, and suitable corrosion inhibitors may also be used. "Strong solution" as referred to herein is a concentrated solution of lithium bromide, which is strong in absorbing power, and "weak solution" is a dilute solution of lithium bromide which is weak in absorbing power.

Referring to FIG. 1, there is shown an absorption refrigeration system comprising a generator **10**, a refrigerant condenser **12**, an absorber **14**, an evaporator **16**, a solution heat exchanger **18** and fluid handling apparatus **20**, connected to provide refrigeration. Weak absorbent solution is directed from heat exchanger **18** through conduit means **22** to generator **10** where the solution is heated by steam supplied to pipe **24**. The absorbent solution is thereby concentrated by vaporizing refrigerant

which passes to condenser **12** through passage **26**. Other types of generators employing a combustible gas may be utilized instead of the arrangement schematically shown.

Water vapor boiled off from the weak solution in the generator **10** is condensed in the condenser **12** and passed to fluid handling apparatus **20** and then passed to evaporator **16**. A heat transfer medium flows through heat exchanger **30** located in the evaporator and is cooled by heat exchange with evaporating refrigerant. A spray header **32** is disposed in the evaporator to wet the surface of the coil **30** with the liquid refrigerant.

Absorbent solution in absorber **14** absorbs water vapor which passes through passage **34** from evaporator **16**. Heat exchangers **36** and **38** connected to a source of cooling medium such as water are located in the absorber **14** and condenser **12**, respectively, to remove waste heat from the refrigeration cycle. Also located in the absorber **14** is spray header **40** which wets the surface of heat exchanger **36** with strong absorbent solution.

Referring now also to the other views of the drawings, fluid handling apparatus **20** preferably comprises a substantially cylindrical hermetic housing **42** which includes a main body portion **44** closed at opposite ends with top and bottom walls **46** and **48**, respectively. While the housing **42** is shown in a vertical position, the fluid handling functions of this invention can be performed with the housing disposed in a horizontal position.

Supported upon top wall **46** of housing **42** is coupling member **50** of magnetic drive means **52**, the member **50** having attached thereto a stub shaft **54** connected to motor means **56**. The exterior location of the motor **56** permits it to be of the conventional air-cooled type, in contrast to more costly solution- or refrigerant-cooled models. The magnetic drive means **52** may be equipped with permanent magnets or electrically energized magnets, which can be located on a relatively large diameter and thereby provide a substantially greater torque transmission.

Located interiorly of the housing **42** in compartment **58** defined by partition **60** and the housing body portion and top wall thereon is matching coupling member **62** of magnetic drive means **52**. Since the member **62** is not submerged in either refrigerant or solution, friction losses, even with a fairly large diameter, are quite low. Connected to the lower surface of the magnetic coupling member **62** and journaled at its upper end in sleeve bearing **64** is main shaft member **66** received at its opposite end in a bearing **68** seated in embossment **70** in the housing bottom wall **48**. The bearings **64** and **68** are desirably formed of a suitable graphite material. Absorbent solution surrounds the lower bearing to lubricate it. Upper bearing **64** is lubricated by refrigerant from passage **96***a*.

Secured to the rotatable main shaft member **66** interiorly of the housing **42** are a plurality of scoop pumps generally designated by the legends P–**1**, P–**2**, P–**3** and P–**4**, four being shown, although the number of pumps provided can obviously be varied depending upon the particular fluid handling functions to be performed. Each pump includes a rotatable collection trough or pan **72**, **74**, **76** and **78** of essentially identical configuration and formed with a relatively flat wall portion **72***a*, **74***a*, **76***a*, and **78***a* integral with an annular flange portion **72***b*, **74***b*, **76***b*, and **78***b* from which extends a radially inwardly directed lip portion **72***c*, **74***c*, **76***c*, and **78***c*. It may be seen that the troughs **72**, **74**, and **76** open upwardly, while the lowermost pan **78** is inverted and thus opens downwardly. The trough **72** defines what may be termed an evaporator circulation and flash cooling chamber **82**, the trough **74** a purge chamber **84**, the trough **76** an absorber circulation chamber **86**, and the trough or pan **78** a generator circulation chamber **88**.

The pump P–**1** has an inlet nozzle **90** connected to conduit **92** leading from the evaporator **16** and an eduction scoop **94** connected to conduit means **96** leading to spray header **32** within the evaporator. It can be seen from FIG. 1 that also communicating with the pan **72** is a conduit **91** having an inlet nozzle **93**. The conduit **91** communicates at its opposite end with the condenser **12** and transfers into the chamber **82** liquid refrigerant at a temperature of approximately 115° F. wherein it flash cools, its temperature being reduced thereby to about 45° F. and is recirculated at this temperature through the evaporator **16** by means of scoop pump P–**1** and conduits **92** and **96** forming a part thereof. The flash vapors released are absorbed by weak solution in chamber **86**. In this manner, the weak or spent solution is more fully utilized and the machine efficiency is markedly increased. If desired, there may be employed in the evaporator circulation chamber **82** as a part of the pump P–**1**, an eliminator **98** taking the form of a flat metal disc attached to the lip portion **72***c* of the trough or pan **72** and provided for the purpose of centrifuging out any droplets which are liberated when flash cooling of the refrigerant occurs in the chamber **82**.

The pump P–**2** has an inlet nozzle **111** for passing weak solution from passage **110** into chamber **84** and another inlet nozzle **100** connected to conduit **102** leading from the absorber **14** for the purpose of passing relatively noncondensable gases from the absorber to chamber **84**. As appears in FIG. 3, the purge nozzle **100** is pointed in the direction of liquid rotation to create a low pressure zone whereby the noncondensable gases are drawn into the rotating solution in purge chamber **74**. The noncondensables, by reason of their relatively low density, tend to adhere to the inner surface of the rotating liquid wherefrom they are skimmed or removed together with weak solution by eduction passage or scoop **104** connected to conduit means **106** leading to the generator. The intimate mixing of the mixture of noncondensables and condensables strips out the water vapor which condenses into the weak solution so that substantially only noncondensables are pumped to the generator.

As is shown in FIGS. 2 and 4, the pump P–**3** includes an inlet nozzle **108** communicating with a conduit **110** leading from the absorber **14** to drain therefrom by gravity weak solution, which is centrifugally impelled outwardly by the rotating pan **76**. A portion of the solution is returned to the absorber by pick-up or eduction scoop **112** connected to conduit means **114**. In this manner, a constant liquid level is maintained in the pan **76**. The pump P–**3**, in accordance with this invention, also embodied an adjustable eduction scoop to vary the volume of solution circulated to the generator, thereby providing a main capacity control for the machine. This scoop is identified by the numeral **116** and connects with conduit means **118** leading to solution heat exchanger **18** which is in communication with the generator **10** by conduit **22**.

Means for adjusting the position of eduction scoop **116** may take many forms and an exemplary arrangement is the linkage of FIG. 2. Conduit **118** may be supported for slidable movement in collar member **120** secured to main body portion **44** of hermetic housing **42**, the conduit having secured thereto a collar **122** pinned as at **126** to link arm **130** and pinned as at **134** to bracket means **138** attached to the housing main body portion **44**. A bellows **140** is connected at **142** to the link arm **130** and is mounted on its base by fixed structure, while a second bellows **144** is attached to conduit **118**. The bellows **140** is connected to a temperature sensing bulb **124** located on leaving chilled water coil **30** to sense the refrigeration demand imposed on the system. For example, and assuming that the control point is set for 45° F., if the leaving chilled water drops below this setting, the bellows **140** will contract, causing pick-up scoop **116** to be withdrawn, thereby reducing machine capacity by reducing solution flow to the generator. Conversely, a rise in leaving chilled water temperature will cause the scoop **116** to be inserted further into the rotating pool of liquid to increase solution flow to generator **10**. Bellows **140** will move inwardly or outwardly and accordingly the depth of penetration of

the scoop **116** in the centrifuging liquid is varied to control the amount of weak solution fed to the generator as a function of refrigeration demand.

The pump P–4, in addition to the inverted trough or pan **78**, includes inlet nozzle **146** connected to conduit means **148** leading from solution heat exchanger **18** which is connected to the generator **10** by a line **150**. In this manner strong solution flows through the conduit **148** and is discharged into the generator circulation chamber **88** to be centrifugally impelled by trough **78** wherefrom it is withdrawn by eduction scoop **154** and directed by conduit means **156** to spray header **40** in the absorber **14**. It can be seen from FIG. 5 that the conduits **148** and **156** have their outer portions relatively close to one another and their orifices **146** and **154** pointed in opposite directions. By locating the inlet nozzle **146** directly behind the eduction orifice **154** in the wake thereof, a sufficiently long circumferential distance is provided within which the scoop pump can reach design velocity and be at its maximum pumping efficiency. Annular flange **152** overlies rotating annular flange **78***c* secured to pan **78** in spaced relation therefrom. Consequently, a liquid seal is formed between flanges **152** and **78***c* which balances any pressure difference between pumps P–1, P–2, P–3, which are at the same pressure, and P–4 with a radial column of liquid during rotation of pan **78**.

Extending vertically in communication with the generator circulation chamber **88** and absorber circulation chamber **86** is what may be termed a clean-up scoop **158** having an eduction opening **160** adjacent the bottom wall **48** of the hermetic housing **42** and terminating in a discharge orifice **162** directed into the absorber circulation pan **76**. The clean-up scoop **158** is connected to the side of housing **44** and is stationary. This scoop is effective to direct into the trough **76** any solution which collects in the bottom of the housing **42** outwardly of the stationary seal means **152**, and which is rotated by movement of pan **78**, thereby reducing drag on the scoop pumps upon start-up, or during operation as a result of splashing. Scoop **158** may rotate with pan **78** if it is relocated adjacent the center of pans **78**, **76** and discharges radially outwardly from the center of the pans.

It is desirable upon machine shutdown that refrigerant and solution intermix in the fluid handling apparatus **20** to prevent solution solidfication or salt crystallization. For this purpose, the annular side walls of the troughs **72**, **74** and **76** mount valves therein which open when rotation of the troughs is terminated to permit drainage of refrigerant and solution to the bottom of the housing. Exemplary door or valve means are shown in FIGS. 3 and 4, the door in the former view being shown in an open position as during liquid drainage. Each door **164** may comprise a tab portion **164***a* attached to the inner surface of trough side wall **74***b* and integral with a relatively flexible flapper portion **164***b* to the back side of which is attached a hook or stop **164***c*. As is shown in FIG. 3, the hook limits the extent of radial inward movement of the flapper in its open position. Rotation of the pans and resulting centrifugal forces together with the weight of the impelled fluid forces the flapper to the closed position of FIG. 4, and when pan rotation is stopped, the flexible character of the door causes it to open and liquid drains freely therethrough. Naturally, each door is located as close as possible to the pan bottom, except the top one **94**. This is to insure a supply of liquid refrigerant for the top sleeve bearing **64**, if this means of bearing lubrication is selected.

The operation of the absorption refrigeration system of this invention is as follows. Assuming rotation of the shaft member **66** through action of the motor **56** and magnetic drive means **52**, each of the pans **72**, **74**, **76** and **78** of pump units P–1, P–2, P–3 and P–4 are thereby caused to rotate with the door or valve means **164** therein in closed position. Liquid refrigerant received from evaporator **16** through conduit **92** and that passed directly to evaporator circulation chamber **82** from the condenser **12**, is centrifugally impelled by the pan **72**; and since the chamber **82** constitutes a low pressure zone, the liquid refrigerant is flash cooled and returned to the evaporator by scoop pump **94** through conduit **96**. The eliminator **98** centrifuges out any droplets liberated during the flashing process, and any vapors released are absorbed principally by weak solution in the absorber circulation chamber **86**.

Simultaneously, noncondensables are induced into purge chamber **84** through purge line **102** into weak solution in pan **84**, are picked up or skimmed by scoop **104** for transfer to the high pressure generator through pipe **106** along with weak solution passing through passage **111**. At the same time, rotation of absorber circulation pan **76** causes additional relatively weak solution to be pumped through conduit **110** from absorber **14** and out discharge orifice **108** into chamber **86** from which it is picked up by scoops **112** and **116**, a portion of the relatively weak solution being returned to the absorber through conduit **114** and another portion being directed to solution heat exchanger **18** and from there to generator **10** through conduit **22**, the weak solution on entry into the generator having the refrigerant boiled therefrom. By adjustment of the depth of penetration of the scoop **116** in the rotating mass of liquid in the absorber circulation chamber **86**, the volume of relatively weak solution sent to the generator **10** through the heat exchanger **18** is controlled in accordance with machine capacity demands.

Simultaneously with the pumping actions described, strong absorbent solution from generator **10** is pumped through conduit **150** and heat exchanger **18** and discharged from orifice **146** of conduit **148** into generator circulation chamber **88** from which the major portion of the rotating bath of liquid is pumped by scoop **154** and through conduit **156** to spray header **40** and absorber **14**. Any stray solution in the chamber **88** is picked up by rotating scoop **158** and transferred to chamber **86** next thereabove.

In this manner, by provision of the fluid handling apparatus **20** of this invention there is accomplished with a single unit refrigerant and absorbent solution circulation, purging and machine capacity control. When the scoop pans are not rotating, refrigenant and solution drain through the open pan doors **164** to intermix and thereby prevent solution solidification.

While a preferred embodiment has been described for purposes of illustration, this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. An absorption refrigeration system comprising a generator for concentrating absorbent solution by vaporizing refrigerant therefrom to form strong absorbent solution; a condenser connected for condensing refrigerant vapor formed in said generator; an evaporator for evaporating the refrigerant liquid therein; and absorber connected to the evaporator for absorbing refrigerant vapor formed therein; and fluid handling apparatus for circulating absorbent solution through said system, said apparatus comprising a hermetic housing, a first scoop pump in said housing including a rotatable pan containing absorbent solution and at least one inlet conduit leading thereto and at least one eduction conduit leading therefrom; a second scoop pump in said housing including a rotatable pan containing liquid therein and at least one inlet conduit leading thereto and at least one eduction conduit leading therefrom; means for rotating said pans; and valve means between said scoop pumps operable when pan rotation ceases to cause the liquid of said second pan to mix with the absorbent solution of said first pan to inhibit solidification of the absorbent solution.

2. An absorption refrigeration system as defined in claim **1**, in which the first rotatable pan contains strong absorbent solution and the second rotatable pan contains weak absorbent solution.

3. An absorption refrigeration system as defined in claim 1, in which the first rotatable pan contains strong absorbent solution and the second rotatable pan contains liquid refrigerant.

4. An absorption refrigeration system as defined in claim 1, wherein said valve means causes the liquids in both said pans to drain therefrom into said housing when said pans cease rotation, and said fluid handling apparatus includes a passage having an inlet end adjacent a lower portion of said shell and a discharge end opening into one of said pans and arranged so that rotation of said pans causes liquid in said shell to be scooped up into said one pan and passed to said generator.

5. An absorption refrigeration system as defined in claim 1, in which valve means is centrifugally actuated, said valve means being closed during pan rotation, and said valve means being centrifugally actuated to an open

position when pan rotation ceases to permit drainage of liquid of one concentration from said pan and its admixture with liquid of a different concentration.

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62—489; 415—89