May 5, 1970 J. ROEDER, JR 3,509,732

ABSORPTION REFRIGERATION SYSTEM

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Fig. 1

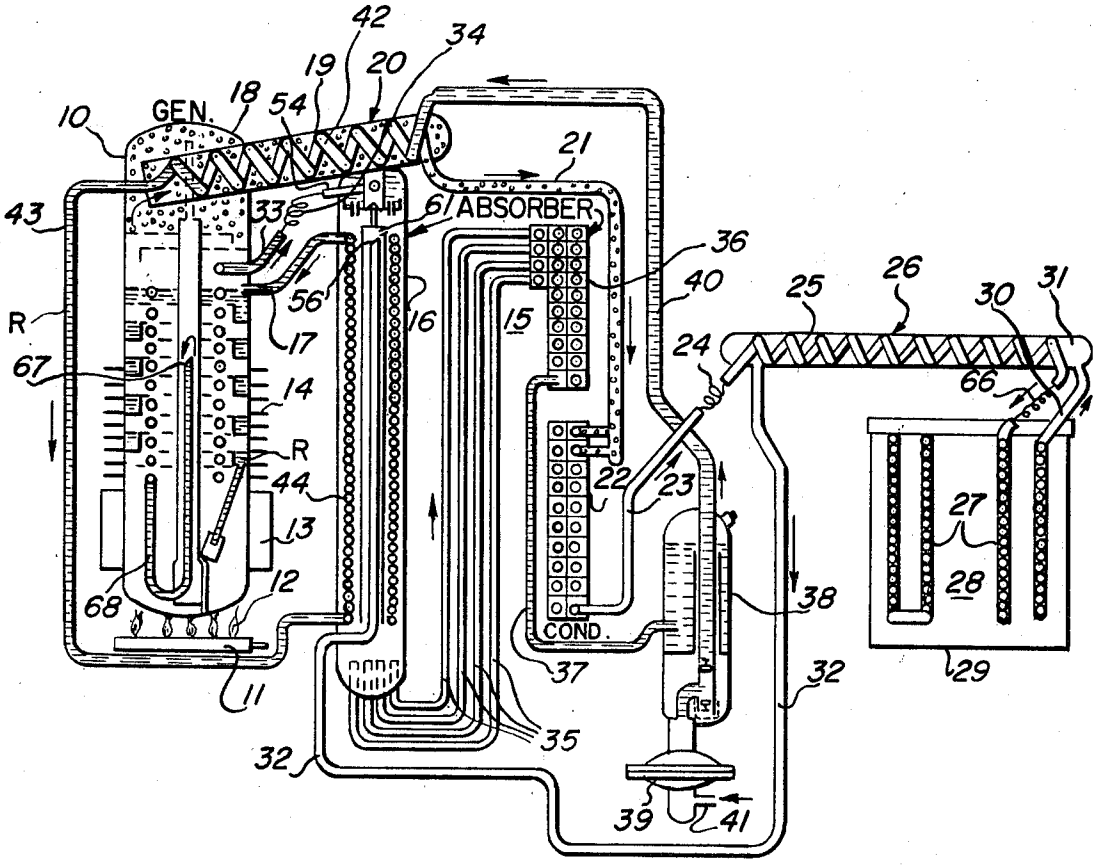
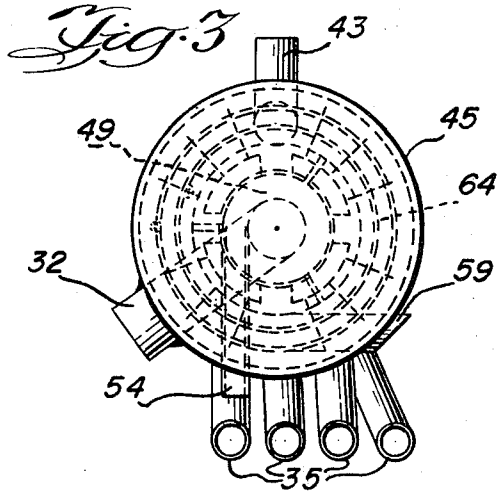


Fig. 3



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Fig. 2

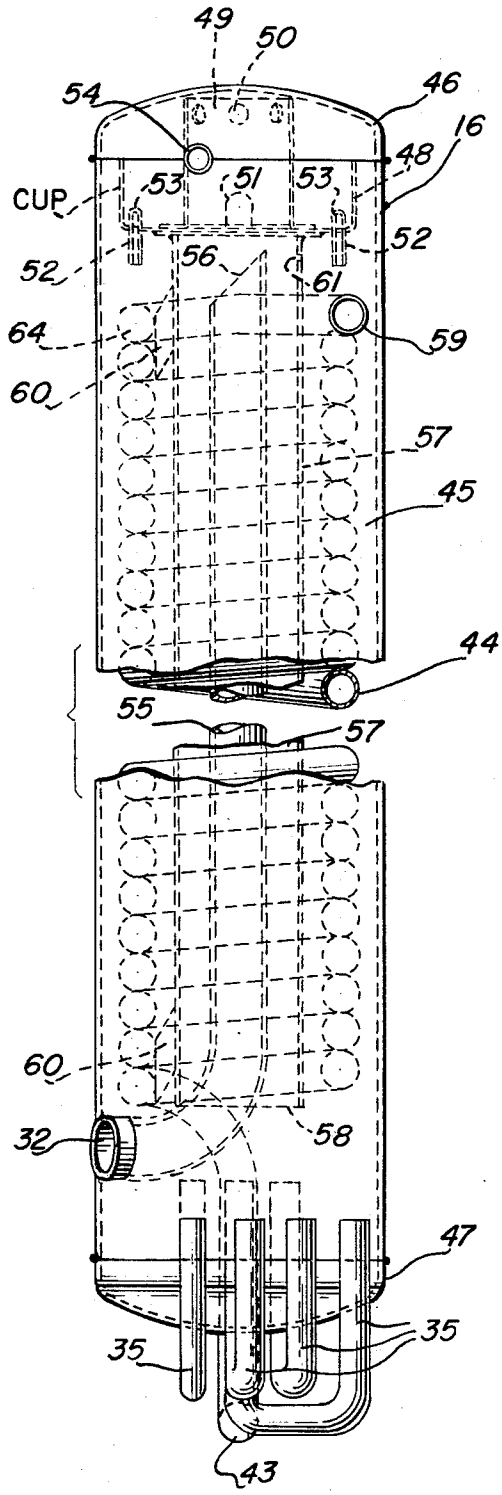


Fig. 4

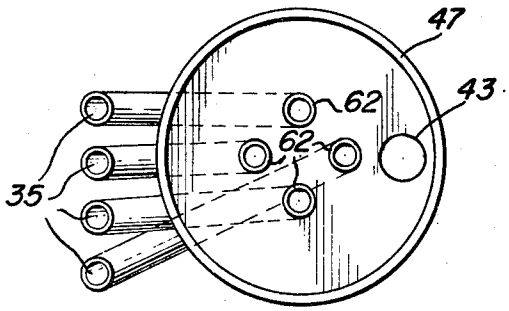
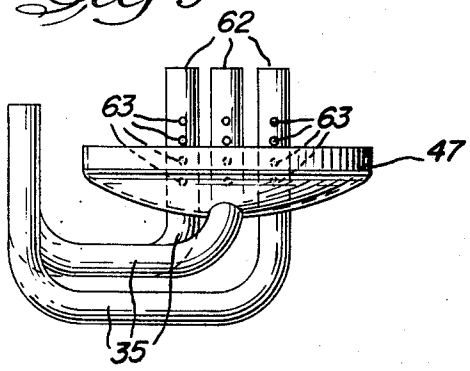


Fig. 5



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3,509,732

ABSORPTION REFRIGERATION SYSTEM

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Int. Cl. F25b 15/00
U.S. Cl. 62—476 7 Claims

This invention relates to an absorber-heat exchanger apparatus for a liquid-gas refrigeration system.

In one well-known form of refrigeration system refrigerant gas such as ammonia is absorbed in a liquid such as water in an absorber portion of the system. One of the features of the the present invention is to provide an improved absorber-heat exchanger apparatus for such a system.

Another feature of the invention is to provide an improved apparatus in such a system for heat exchange between liquid refrigerant flowing to an evaporator and gaseous refrigerant flowing from the evaporator together with improved means for retarding the flow of gaseous refrigerant into the liquid refrigerant portion of the heat exchanger to prevent this portion operating as a condenser which would retard flow of liquid refrigerant through the heat exchanger.

Other features and advantages of the invention will be apparent from the following description of one embodiment thereof taken in conjunction with the accompanying drawings. Of the drawings:

FIG. 1 is a semi-diagrammatic representation of a liquid-gas refrigeration system having parts thereof embodying the invention and with certain parts shown in section and others in side elevation.

FIG. 2 is a side elevational view of an absorber-heat exchanger portion of the apparatus.

FIG. 3 is a plan view of the apparatus of FIG. 2.

FIG. 4 is a plan view of the separated bottom part of the apparatus of FIG. 2.

FIG. 5 is a side elevational view of the part of FIG. 4.

In the representation of the entire system as shown in FIG. 1 there is prvidod a generatr **10** shown here semi-diagrammatically but described more fully and claimed in the copending application of B. A. Phillips, Ser. No. 502,186, filed Oct. 21, 1965, assigned to the same assignee as the present application.

The generator **10** is in the form of a vertical cylinder that is heated on the bottom by a gas burner **11** providing a circle of flame **12** around the bottom of the generator. For more efficient heat transfer the lower sides of the generator **10** are provided with spaced vertical vanes **13** with additional vanes **14** provided above the vanes **13**.

The apparatus includes an absorber **15** which is in two principal parts with one part being a vertical heat exchanger **16** and the other part **36** being a coil absorber portion of the type disclosed and claimed in the copending application of E. P. Whitlow et al. Ser. No. 370,269, filed May 26, 1964, also assigned to the same assignee as the present application.

The generator **10** is of a "flooded" type and when in operation is filled to slightly below an an inlet pipe **17** for liquid rich in dissolved refrigerant. In the generator **10** the dissolved refrigerant such as ammonia is boiled off and rises to the top **18** of the generator as a gas, as indicated in FIGURE 1. This gas flows through an outwardly extending tube **19** that forms a part of a heat exchanger **20** and from there flows through a pipe **21** to an ordinary condenser **22** of the type illustrated in E. P. Whitlow copending application Ser. No. 370,327, filed May 26, 1964, now Patent 3,236,064, and also assigned to the same assignee as the present application.

In the condenser **22** the gaseous refrigerant is converted into liquid refrigerant and the liquid refrigerant flows outwardly through a pipe **23** and a flow restrictor such as a capillary **24**.

After flow through the capillary **24** the liquid refrigerant passes through the internal helical coil **25** of a heat exchanger **26**. On leaving the coil **25** of the heat exchanger the liquid refrigerant passes through a second flow restrictor such as the capillary **66** into the evaporator **27** which is chilled by evaporation of the liquid refrigerant therein in the customary manner. This evaporator **27** is surrounded by a liquid **28** such as water plus an antifreeze material in a container **29** to chill the liquid. The liquid is then pumped by means (not shown) in the customary manner to the desired location for providing a desired cooling effect at this location.

In the evaporator **27** the liquid refrigerant of course evaporates and becomes gaseous refrigerant. This gaseous refrigerant flows from the evaporator through a pipe **30** into the interior **31** of the heat exchanger **26** where it passes over the coil **25** containing the incoming liquid refrigerant, as previously described, in heat exchange relationship therewith.

From the heat exchanger **26** the gaseous refrigerant or rich gas flows through the pipe **32** into the heat exchanger portion **16** of the absorber. This portion of the apparatus will be described in greater detail hereinafter.

In the absorber portion **16** the rich gas from the pipe **32** is partially absorbed in weak liquid flowing into the absorber portion **16** through the outlet pipe **33** and capillary **34** from the generator **10**.

Partial rich liquid and unabsorbed refrigerant gas flow from the bottom of the absorber portion **16** through the plurality of pipes **35** respectively connecting to inlets to the coil portion **36** of absorber **15**. In this coil portion **36** absorption is complete so that the liquid flowing from the absorber portion **36** through the pipe **37** is liquid rich in dissolved refrigerant.

The rich liquid from the absorber **15** flowing through the pipe **37** enters a receiver **38** and is pumped by means of a pump **39** up a pipe **40** to the heat exchanger **20**. The pump **39** is a diaphragm which is operated by hydraulic fluid supplied through a line **41**.

The rich liquid from the pipe **40** flows through a helical coil **42** in the heat exchanger **20**. The rich liquid in this coil flows countercurrently in heat exchange relationship to the hot refrigerant gas flowing outwardly through the tube **19** in a manner previously described. With this arrangement the rich liquid is heated and the hot gas from the generator is cooled before passing to the condenser **22** in the manner previously described.

From the heat exchanger **20** at the top of the generator the rich liquid flows through a pipe **43** to the bottom of a vertical helical coil **44** forming a part of the heat exchanger portion **16** of the absorber **15**. From the top of this coil **44** the rich liquid flows through the rich liquid inlet pipe **17** to the generator **10** to complete the circuit.

A very important part of the liquid-gas refrigeration system described in the absorber-heat exchanger part **16**

shown in detail in FIGS. 2–5 inclusive. This heat exchanger **16** comprises a vertical generally cylindrical container **45** closed at the top by a cap **46** and at the bottom by a similar cap **47**. The helical coil **44** is arranged vertically and substantially concentrically within the cylinder **45** and spaced inwardly from the walls thereof.

Positioned within the cylinder **45** at the top thereof and above the top of the helical coil **44** is a first cup **48**. Located within this first cup **48** is a second inverted cup **49** of smaller diameter than the first cup **48** and substantially concentric therewith. This second cup **49** is provided with a plurality of holes **50** adjacent its top and a plurality of cutout openings **51** at the bottom and within the confines of the sides of the first cup **48**.

Extending through the bottom of the first cup **48** and above the coils of the helix **44** are a plurality of vertically extending small tubes **52** arranged generally in a circle. To avoid confusion, FIG. 2 illustrates only 2 of these tubes **52** with the two selected being located diametrically opposite each other. The top of each small tube **52** is provided with a hole **53** having an area less than the cross sectional area of its tube **52**.

Weak liquid from the generator **10** and capillary **34** is directed into the interior of the second inverted cup **49** through a pipe **54** that is arranged tangentially to the cup **49** as illustrated most clearly in FIG. 3.

At the bottom of the absorber-heat exchanger apparatus **16** the rich gas pipe **32** previously described enters the coil **45** and extends upwardly as a pipe extension **55**. This pipe extension **55** is substantially concentric with cylinder **45** and helical coil **44** and is provided with a sloped outlet end **56** substantially between the top of the helical coil **44** and the bottom of the first cup **48**. This outlet end is sloped as shown in FIG. 2 in order that the end of this pipe will not be accidentally blocked by positioning the cup **48** against it in assembling the apparatus.

Extending downwardly from the cup **48** and located between the pipe extension **55** and the helical coil **44** is a tube **57**. This tube **57** is spaced from both the coil **44** and the pipe **55** and is concentric with these and with the vertical cylinder **45**. The lower end **58** of this tube is open adjacent the bottom of the cylinder **45**.

The rich liquid pipe **43** previously described enters the apparatus **16** at the bottom and continues upwardly in the apparatus **16** as helical coil **44**. The upper outlet end **59** of this rich liquid helical coil **44** is located at the top of the apparatus **16** and is attached to the rich liquid inlet pipe **17** of the generator **10** as previously described.

The tube **57** and the helical coil **44** are anchored to each other and held in spaced relationship as described above by three equally spaced spacers **60** at the top and bottom of the coil **44**.

As previously described, the rich gas flows into the absorber portion **16** through the pipe **32**. It leaves the pipe extension **55** at the outlet end **56** that is adjacent the top of the tube **57** and then flows downwardly in the tube **57** in the space between the tube and the pipe extension **55**. Non-refrigerant gases in the rich gas are bled out of the interior of the tube **57** through a small bleed hole **61** at the top of the tube.

The refrigerant gas flowing downwardly in the tube **57** leaves the tube at the lower outlet end **58**. Here it mixes with the weak liquid flowing over the helical coil **44** from the small upper tubes **52** so that the refrigerant gas becomes partially absorbed in the weak liquid. The resulting liquid and refrigerant gas then flows through the pipes **35** into the coil portion **36** of the absorber **15**.

In the embodiment illustrated there are four of these pipes **35**, each having an inner end **62** within the bottom of the cylinder **45**. In order to illustrate these inner ends **62** more clearly, FIGS. 4 and 5 show the bottom cap **47** of the cylinder and the ends of the pipes **35** attached thereto.

As is shown in FIG. 5, each inner end **62** of the pipes **35** contains a plurality of small holes **63**, here shown as four. The holes or liquid openings **63** are formed along the axis of the respective pipes **35** and are preferably all of the same size. The respective holes are horizontally aligned with the corresponding holes of the other pipes so that each pipe has the same number of liquid openings at a given liquid level in the bottom of the cylinder **45**. This arrangement thus provides means for metering the flow of liquid into the pipes **35** so that each of them carries a substantially equal portion of the fluid to the coil portion **36** of the absorber **15**. In addition, the above-described metering means effectively prevents slugging of liquid into the coil portion **36** of the absorber **15**. Liquid slugging would occur if the openings **63** were not included and liquid was forced to enter the pipes **35** through the vapor entry openings at the ends of the pipes.

The capillary **34** in the weak liquid outlet pipe **33** from the generator **10** separates the high pressure interior of the generator from the relatively low pressure absorber. Thus, in one embodiment this capillary lowered the pressure from 300 p.s.i. in the generator to about 55 p.s.i. in the absorber. The weak liquid flowing through the pipe **54** into the first cup **48** rises in this cup to the tops of the circularly arranged vertical tubes **52**. The liquid then flows through the small openings **53** the tops of the vertical tubes **52** and down onto the top turn **64** of the helical coil **44**. This weak liquid absorbent solution flows down over the successive turns absorbing refrigerant gas on the way and collects in a pocket at the bottom of the cylinder **45** and within the bottom cap **47**. The mixture of partial rich liquid and unabsorbed refrigerant gas then enters the pipes **35** by way of the plurality of small holes **43** and the pressure of the refrigerant gas in the pipes **45** forces the mixture of partially strong liquid and refrigerant gas through the pipes **45** into the coil portion **36** of the absorber **15**.

As mentioned earlier, the weak liquid passage **54** enters the inverted cup **49** at the top of the absorber part cylinder **45** at a tangent. The liquid falls to the bottom of the inverted cup and flows out through the openings **51** into the larger cup **48** for flow over the helical coil **44** as described. The refrigerant gas in the weak liquid within the cup **49** flows outwardly through the top openings **50** therein. The small openings **53** at the top of each vertical tube **52** are provided so that the flow through the series of tubes is substantially uniform. It is much easier to have uniform sizes in the series of small openings **53** than it is to provide uniform diameters to the small tubes **52**. If the small openings were not substantially the same size and one was substantially larger than the others this one would tend to siphon off most of the liquid so that flow down and over the turns of the helical coil **44** would be non-uniform. The small openings **53** at the tops of vertical tubes **52** have an additional advantage in that it is much more difficult for oil and other contaminants to interfere with the liquid flow through the openings **53** than it would be through the tubes **52**. In one construction these drip tubes **52** were not spaced directly above the center of the topmost turn **64** of the coil **44** but were staggered on opposite sides of the center in order to get even distribution of liquid on both sides of the coil. It was found in actual production that it was almost impossible to center each tube **52** over the helical coil **44**. Therefore, they were deliberately offset from the center but staggered as described.

As briefly described earlier, the capillary **24** at the entrance to the heat exchanger **26** is used to retard entry of gaseous refrigerant from the condenser **22** into the coil **25** within the heat exchanger **26**. If this should occur, the coil **25** would then function as a condenser to condense this unwanted gaseous refrigerant. During any operation of coil **25** as a condenser, flow of liquid refrigerant through the heat exchanger **26** to the evaporator **27**

would be interferred with. Furthermore, to make matters worse, if the coil **25** were operating as a condenser it would continue to do so as the reduced pressure brought about by the condensing action would draw more refrigerant gas from the condenser. This would occur also because the condenser **22** is on the high pressure side of the system. This malfunctioning of the coil **25** portion of the liquid refrigerant pipe **23** has been found in practice to occur at any time if the temperature of the liquid **28** surrounding the evaporator **27** is within 2° F. of the temperature in the evaporator **27**. When this small temperature difference occurs, some of the liquid refrigerant will not evaporate in the evaporator **27** but will flow through the outlet pipe **30** into the interior **31** of the heat exchanger **26**. This will have the effect of subcooling the outlet end of the liquid refrigerant coil **25** in the heat exchanger **26**. This would tend to further draw gaseous refrigerant from the condenser **22** into the heat exchanger **26** so that it would malfunction as a condenser, as previously described.

By providing the capillary **24** in the liquid refrigerant line **23** at the entrance to the helical coil **25** this flow of gaseous refrigerant into the coil is substantially prevented. Similarly, the providing of a second capillary **66** at the outlet end of the heat exchanger coil **25** and before the evaporator **27** also retards flow from the condenser **22** to the evaporator **27** with the result that the flow of gaseous refrigerant into the coil **25** is further retarded. Thus, the capillaries **24** and **66** function together to prevent substantially the flow of gaseous refrigerant into the heat exchanger coil **25** so that it cannot function as a condenser.

As is shown in FIG. 1, the exit end **56** of the rich gas pipe **32** is at a relatively high level. The volume of liquid storage in the absorber vertical heat exchanger **16** below exit end **56** is greater than the volume of liquid leaving the generator **10**. This arrangement is provided so that when the system is shut off weak liquid cannot enter the pipe **32** and flow into the evaporator **27**. If weak liquid did happen to fill the evaporator **27** it would take a considerable time after again starting up the apparatus for the rich gas flowing through the tube **19** and pipe **21** to convert the weak liquid in the evaporator to rich liquid and build up enough pressure to force the weak liquid from the evaporator. Furthermore, if this occurred, there would be considerable danger of the generator **10** overheating in its attempt to build up enough refrigerant gas pressure to force the liquid out of the evaporator.

Having described my invention as related to the embodiment shown in the accompanying drawings, it is my intention that the invention be not limited by any of the details of description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

The embodiment of the invention in which an exclusive property or privilege is claimed is defined as follows:

1. Absorber-heat exchanger apparatus for a liquid-gas refrigeration system, comprising: means providing a chamber; enclosed liquid conduit means having an outer surface within said chamber, said conduit means being in the form of a substantially vertical helix within said chamber; means for flowing a weak absorbent solution over the outer surface of said coil in heat exchange relationship therewith comprising a liquid distributing cup member above the topmost individual coil in said helix having a plurality of outlets above the topmost coil for flowing said solution over said topmost coil and then succeeding coils; and means for supplying to said chamber a gaseous refrigerant in contact with said solution to enrich the solution.

2. The apparatus of claim **1** wherein each said conduit member has an entrance opening for said solution smaller than the cross sectional area of its conduit member.

3. The apparatus of claim **1** wherein said liquid receiving member comprises a first cup in said chamber in which said plurality of conduit members are located and an inverted second cup within said first cup having spaced liquid flow means communicating with said first cup and gaseous flow means communicating with said chamber, and said means for flowing said solution comprises a conduit emptying into said second cup.

4. Absorber-heat exchanger apparatus for a liquid-gas refrigeration system, comprising: means providing a chamber; enclosed liquid conduit means having an outer surface within said chamber, said conduit means being in the form of a substantially vertical helix within said chamber; means for flowing a weak absorbent solution over the outer surface of said helix in heat exchange relationship therewith; and means for supplying to said chamber a gaseous refrigerant in contact with said solution to enrich the solution, said means for supplying said gaseous refrigerant comprising conduit means emptying into said chamber at an area adjacent the bottom of said helix, said conduit means comprising a first conduit in said chamber having an exit end adjacent the top of said helix and a second conduit enclosing but spaced from said first conduit having an exit adjacent the bottom of said helix.

5. Absorber-heat exchanger apparatus for a liquid-gas refrigeration system, comprising: means providing a chamber; enclosed liquid conduit means having an outer surface within said chamber, said conduit means being in the form of a substantially vertical helix within said chamber; means for flowing a weak absorbent solution over the outer surface of said coil in heat exchange relationship therewith comprising a liquid distributing member above the topmost individual coil in said helix having a plurality of outlets located above said topmost coil for flowing said solution over said topmost coil and then succeeding coils, said liquid distributing member comprising a liquid receiving member having a plurality of conduit members providing said outlets, the liquid receiving member comprising a first cup in said chamber in which said plurality of conduit members are located and an inverted second cup within said first cup having spaced liquid flow means communicating with said first cup and gaseous flow means communicating with said chamber, and said means for flowing said solution comprises a conduit emptying into said second cup; and means for supplying to said chamber a gaseous refrigerant in contact with said solution to enrich the solution, said means for supplying said gaseous refrigerant comprising conduit means emptying into said chamber at an area adjacent the bottom of said helix and the conduit means comprising a first conduit in said chamber having an exit end adjacent the top of said helix and a second conduit enclosing but spaced from said first conduit having an exit adjacent the bottom of said helix.

6. Absorber-heat exchanger apparatus for a liquid-gas refrigeration system, comprising: means providing a chamber; means for supplying to said chamber an absorbent solution; means for supplying to said chamber refrigerant vapor to contact the absorbent solution for partial absorption of the refrigerant vapor in the absorbent solution; a coil absorber for completing absorption of unabsorbed refrigerant vapor in the absorbent solution; and conduit means connecting said chamber to said coil absorber for transfer of fluid from said chamber to said coil absorber, said conduit means including means for metering fluid flow to insure equal distribution of fluid to all parts of said coil absorber, the coil absorber having a plurality of inlets, the conduits means comprises a plurality of pipes connecting to said inlets, and the means for metering fluid flow comprises means forming small liquid openings at the inlet ends of the pipes.

7. Absorber-heat exchanger apparatus as claimed in claim **6** wherein the means forming small liquid openings comprises a series of holes along the axis of each pipe, with the holes of each pipe being horizontally aligned with the corresponding holes of the other pipes

so that each pipe has the same number of liquid openings at a given liquid level.

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