Nov. 13, 1962 B. A. PHILLIPS ET AL 3,063,257

DEFROSTING APPARATUS FOR AN ABSORPTION REFRIGERATOR

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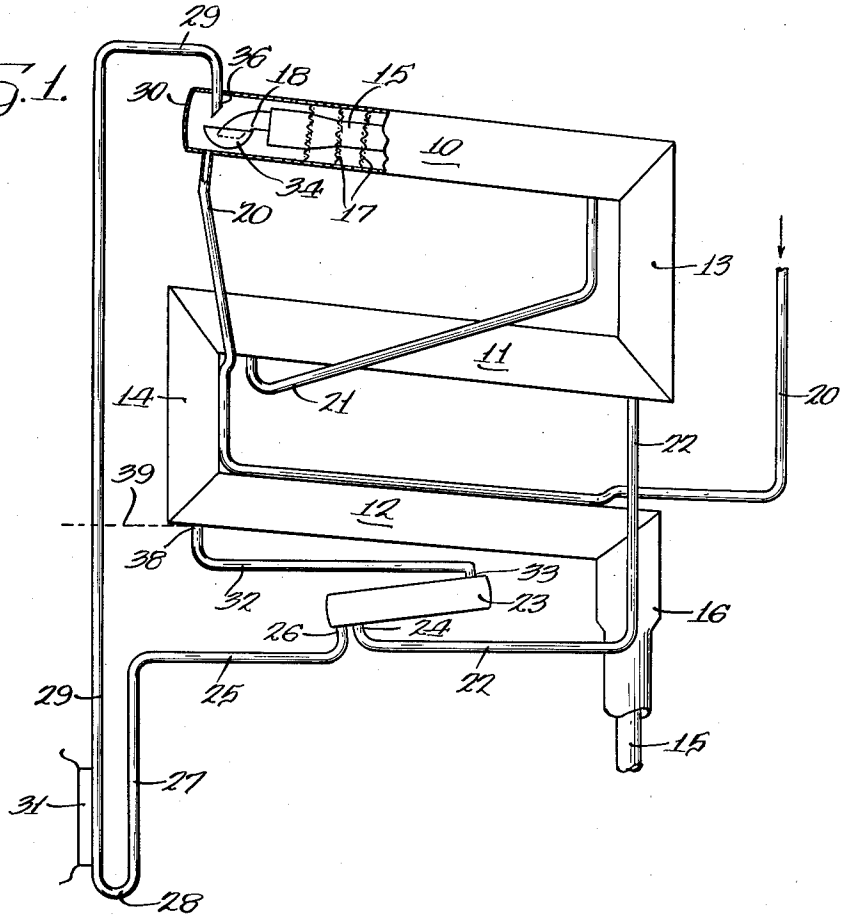
Fig. 1.



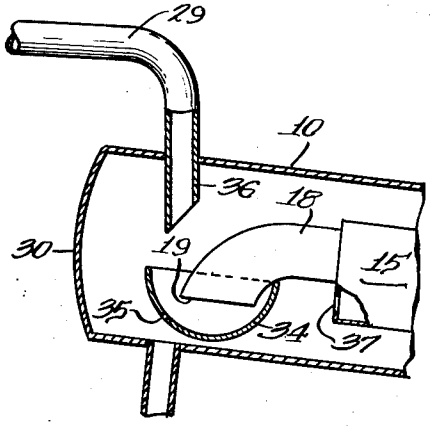


Fig. 2.

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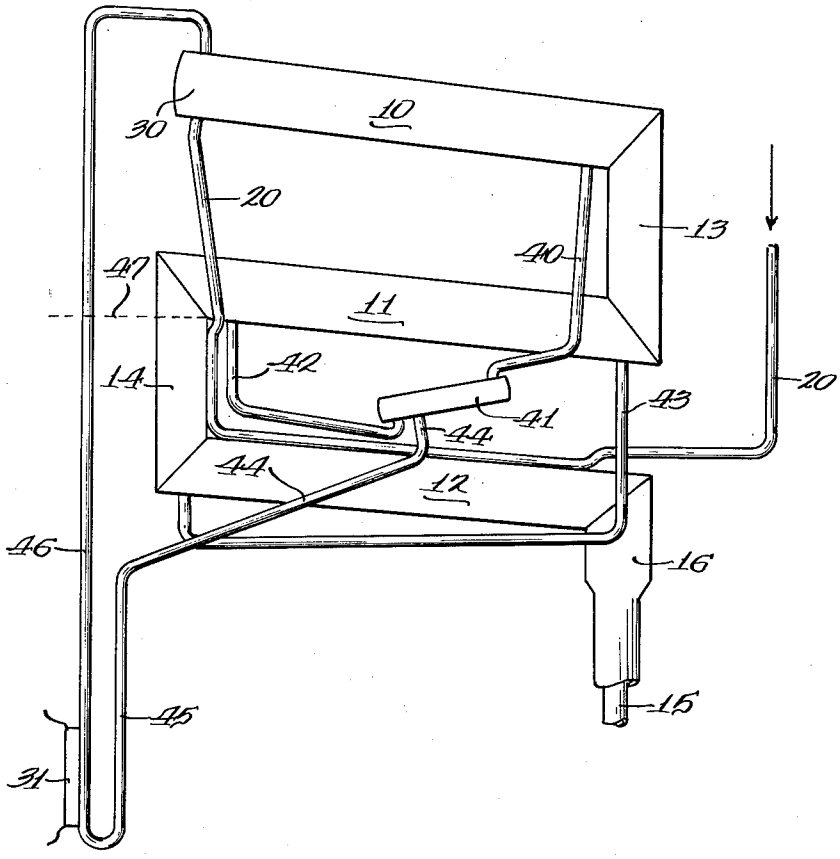
Fig. 3.



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DEFROSTING APPARATUS FOR AN ABSORPTION REFRIGERATOR

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11 Claims. (Cl. 62—275)

This invention relates to a defrosting apparatus for a refrigeration evaporator and particularly to such an evaporator used in an absorption refrigeration system.

One of the features of this invention is to provide an improved defrosting apparatus in which means are provided for heating a refrigerant and means are provided for conducting this heated refrigerant into heat exchange relationship with the evaporator to defrost the evaporator.

Another feature of the invention is to provide such a defrosting apparatus in which a reservoir of liquid refrigerant is maintained at all times and refrigerant from this reservoir is periodically heated and vaporized and conveyed to the evaporator for achieving said defrosting.

A more specific feature of the invention is to provide such an apparatus in which means are included for removing moisture from the refrigerant in the reservoir.

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

FIGURE 1 is a fragmentary elevational view of a portion of an absorption refrigeration system partially broken away for clarity of illustration and illustrating one embodiment of the invention.

FIGURE 2 is an enlarged sectional elevational view of one portion of the apparatus of FIGURE 1.

FIGURE 3 is a view similar to FIGURE 1 but illustrating a second embodiment of the invention.

The refrigeration system illustrated herein is generally similar to that shown, described and claimed in the copending application of Benjamin A. Phillips, Serial No. 778,370 filed December 5, 1958 and assigned to the same assignee as is the present invention. In the accompanying drawings only those portions of the system are shown that are necessary to illustrate the invention.

In the embodiment of FIGURES 1 and 2 there is provided a relatively low temperature first evaporator tube **10**, a relatively higher temperature second evaporator tube **11**, both inclined to the horizontal, a heat exchanger tube **12** also inclined to the horizontal and connecting substantially vertical tubes **13** and **14** to connect all tubes in series. There is also provided a pipe **15** for inert gas leading from an absorber (not shown) extending interiorly of a connector tube **16** also leading to the absorber. The pipe **15** is located on the interior of tubes **10** to **14** and **16** in heat exchange relationship therewith. The portion of the pipe **15** within the evaporators is provided with radially extending inclined fins **17** as shown diagrammatically in FIGURE 1. The extreme upper end of the pipe **15** is provided with a downwardly extending extension **18** having its extreme outer end **19** open and bent downwardly.

Leading from an ordinary refrigerant condenser (not shown) is a pipe **20** for liquid refrigerant. As is illustrated this pipe is attached to the exterior surfaces of the heat exchanger tube **12** and the vertical tube **14** in order to be cooled by the surfaces. The pipe **20** then extends upwardly to connect to the upper bottom surface of the first evaporator tube **10**. Thus the pipe **20** conveys liquid refrigerant into the evaporator sections and serves to precool the refrigerant during its passage.

As can be seen, the refrigeration system illustrated here is of the uniform pressure absorption type in which an inert gas or auxiliary pressure equalizing fluid is employed. In such a system the refrigerant may be ammonia, the inert gas may be hydrogen and the absorption liquid may be water, which will thereby form a solution with the ammonia refrigerant. In such a system a generator is used to boil off ammonia gas from a liquid rich in dissolved ammonia. The ammonia gas is then conveyed to a condenser where it is condensed to a liquid form before being conveyed into the evaporator for subsequent evaporation and cooling. Thus in the illustrated embodiment here, the hydrogen gas flows up through the pipe **15** to the extreme upper end of the evaporator **10**. The liquid refrigerant from the pipe **20** also enters at this end and the liquid refrigerant evaporates into the hydrogen to produce the cooling effect.

The mixture of liquid refrigerant, gas refrigerant and hydrogen flows by gravity down through the first evaporator **10**. The remaining liquid refrigerant then flows down through a connecting pipe **21** to the upper end of the second evaporator **11**. The gas refrigerant and hydrogen flow down through the tube **13** into the second evaporator **11**. The liquid refrigerant from the pipe **21** flows down the second evaporator **11** and evaporates therein into the mixed atmosphere of hydrogen and gaseous refrigerant. From the lower end of the second evaporator **11** liquid refrigerant flows down through a pipe **22** into an accumulator chamber **23**. The liquid refrigerant pipe **22** is connected to the chamber **23** at an inlet **24**. The chamber **23** is inclined downwardly from this inlet **24** and is connected to a pipe **25** at an outlet **26** from the chamber **23**. This pipe **25** is provided with a depending loop **27** providing a reservoir having a lower portion **28**. One leg **29** of the loop extends from this lower portion **28** upwardly to empty into the top of the upper portion **30** of the first evaporator **10**. The leg **29** adjacent the lower portion **28** is provided with an electric heater **31** for heating the contents of the loop **27** at the lower end of the leg **29**.

The accumulator chamber **23** is provided with another pipe **32** having an inlet end **33** above the chamber inlet **24**. Pipe **32** empties into the upper end of the heat exchanger **12**. Liquid refrigerant flowing through the pipe **32** into the heat exchanger **12** then evaporates within the heat exchanger **12** into the atmosphere of mixed hydrogen and gaseous refrigerant. The resulting rich mixture of refrigerant and hydrogen then flows down through the connector tube **16** into the absorber (not shown).

Located within the upper end **30** of the evaporator **10** is a substantially hemispherical dish **34** having a small opening **35** adjacent its bottom. The dish **34** is located beneath the inner end **36** of the leg **29** and the outer end **19** of the inert gas pipe extension **18** extends within the dish **34** to beneath the upper edge thereof. The adjacent end of the gas pipe **15** is provided with a small opening **37** for bleeding the inert gas at all times from this pipe into the interior of the evaporator **10**.

At a normal refrigerating operation of the apparatus the inert gas, hydrogen, flows upwardly through the pipe **15** and empties by way of the extension **18** into the upper end **30** of the first evaporator **10**. Some of the liquid refrigerant from the pipe **20** evaporates into the inert atmosphere within the evaporator **10** while the remainder of the liquid refrigerant flows down the inside of the evaporator **10** to the lower end thereof and from this end through the pipe **21** into the upper end of the second evaporator **11**. In the meantime mixed inert gas and gaseous refrigerant flows from the evaporator **10** down into the vertical tube **13** and the second evaporator **11**.

Liquid refrigerant from the pipe **21** entering the upper end of the second evaporator **11** evaporates into the gaseous atmosphere in the evaporator **11** to produce further refrigerating effect. The remaining liquid refrigerant flows down the bottom of the second evaporator **11** to the lower end thereof and then through the pipe **22**, chamber **23** and pipe **32** into the upper end of the heat exchanger **12**. Mixed inert gas and refrigerant gas flows from the evaporator **11** down through the tube **14** into the heat exchanger **12**. Liquid refrigerant from the pipe **32** evaporates into this atmosphere and the resulting relatively rich gas then flows down through the tube **16** to the absorber (not shown).

Liquid refrigerant from the chamber **23** flows into the pipe **25** and the loop **27**. The liquid level in the system made up of the pipes **22**, **25**, **27**, **29** and **32** and the chamber **23** is determined by the level of the end **38** of the pipe **32** where it empties into the heat exhcanger **12**. This liquid level line is indicated in FIGURE 1 at **39**.

When it is desired to defrost the evaporators the electric heater **31** is energized either manually or by a timer. When a timer is used the defrosting occurs generally once every 24 hours. The heat generated by the heater **31** vaporizes some of the liquid refrigerant in the tube leg **29** which thereupon becomes a lift tube. Then by gas-lift action the hot mixture of liquid refrigerant and gaseous refrigerant is lifted upwardly in the pipe **29** into the evaporator **10**. This hot mixture flowing out the inner end of the pipe **29** first separates into liquid and vapor, and the liquid substantially fills the dish **34** and then flows down through the evaporators **10** and **11** to warm them and remove frost therefrom. The substantial filling of the dish **34** with the hot liquid refrigerant blocks the end **19** of the inert gas pipe extension **18** to reduce substantially the flow of inert gas. Thus a liquid seal is provided to stop gas flow through the main passage **19**. A limited gas flow continues through opening **37**. This limited gas flow mixing with the vapor entering at **36** results in a gas of high ammonia concentration. The ammonia dew point of this gas is to be well above 32°, so that ammonia condensing out of the gas will warm the tubing above 32°, thus defrosting the evaporators.

As the refrigeration system continues to operate, either because the usual thermostat switch is usually mounted adjacent the evaporator circuit and has been warmed up or because it was operating at the beginning of the defrost cycle, liquid refrigerant continues to be supplied through the pipe **20**. This together with the ammonia condensing in the cold tubes serves to replenish the refrigerant in the accumulator chamber **23**, the pipe **25**, and the loop **27**.

At the end of the defrost cycle which is customarily about 15 to 20 minutes, the electric heater **31** is deenergized. Shortly after this the supply of vapor and heated liquid through the leg **29** by the gas-lift pumping action is stopped. Liquid within the dish **34** then drains out the opening **35** to break the liquid seal at the outer end **19** of the gas pipe **15** and permit the inert gas to resume its normal flow. The refrigeration system thereupon operates in its normal manner.

During the normal refrigeration cycle the lower end of pipe **22** and pipe **25**, loop **27**, pipe **32** and accumulator chamber **23** will be filled with liquid refrigerant containing some water up to the liquid level as indicated by the line **39**. Thus there is always a stored amount of predominantly liquid refrigerant available at all times in preparation for the defrost cycle. During the defrosting there is provided a closed circuit from heater **31**, through the leg **29** and evaporators **10** and **11** and through the pipes **22** and **25** and accumulator **23** into the loop **27**. Thus everything beneath the liquid level **39** serves as a reservoir for liquid refrigerant for use during the defrosting cycle. During the defrosting any gaseous refrigerant that does not condense in the defrosting operation eventually flows gack to the absorber and the generator (not shown).

At the time of first start-up of a refrigeration system utilizing the present invention, there may be a surplus of water within the accumulator **23**. Since a solution having an excess amount of water has a substantially higher boiling point, it is desirable to remove the water quickly. The heavier water solution tends to settle in the lower end of accumulator **23**, but the refrigerant entering the accumulator from pipe **22** is caused to bubble up through the water, which action carries the water solution out with the ammonia refrigerant passing up through accumulator **23** and out through pipe **32**.

In the second embodiment shown in FIGURE 3, identical numerals are used on identical parts. In this embodiment, as in the first embodiment, inert gas flows into the system through the pipe **16** and liquid refrigerant flows into the system through the pipe **20**. The refrigerant and gas mixture then flows down the circuit including the first evaporator **10**, tube **13**, second evaporator **11**, tube **14** and heat exchanger **12**. In this embodiment, however, the liquid refrigerant for defrost purposes is taken from the lower end of the first evaporator **10** by way of a pipe **40** instead of from the lower end of the second evaporator **11** by way of the pipe **22** as shown in the first embodiment. The pipe **40** connects to the upper end of downwardly inclined accumulator chamber **41** and from a lower end of this chamber a pipe **42** conveys liquid refrigerant to the upper end of the second evaporator **11**. A pipe **43** conveys liquid refrigerant from the lower end of the second evaporator **11** to the upper end of the heat exchanger **12**.

A pipe **44** extends from the accumulator **41** at a level above the accumulator end of the pipe **42** and connects to a downwardly extending loop **45** similar to the loop **27** of the first embodiment and also provides with an upwardly extending leg **46** that connects to the upper end **30** of the first evaporator **10**.

In the second embodiment the heavier entrained water and liquid refrigerant tends to flow toward the lower end of the inclined accumulator chamber **41**. From here it flows through the pipe **42** into the upper end of the second evaporator **11**. The lighter refrigerant entering through pipe **40** then will substantially float on the heavier liquid inthe accumulator chamber **41**, and by means of piston action actually forces the heavier liquid out through pipe **42** and pipe **44**. Experimental results indicate this method of purging the system of water is much faster than that obtained with the structure shown in FIGURE 1.

Another advantage of the second embodiment of FIGURE 3 is that the liquid refrigerant is taken from the first or freezer evaporator **10** and placed in the defrost circuit so that the defrost circuit is always supplied with refrigerant in liquid form up to approximately the liquid level indicated by the line **47**, regardless of the cooling demand on the system. In the embodiment of FIGURE 1 the liquid refrigerant is not fed into the defrost circuit until it reaches the lower end of the second evaporator **11**. This means that if the demand for cooling has been excessive so that there has been an abnormally high evaporation of liquid refrigerant there may be little or no refrigerant left in liquid form by the time it reaches the end of the evaporator **11** and the entrance to the defrost circuit feeder pipe **22**.

In the defrosting system of this invention the vaporized heated refrigerant supplies the majority of the defrost heat. However, the heated liquid also supplies heat for defrosting. As the heated refrigerant vapor is carried through the evaporator system by the gas flow, it condenses on any area which is at low temperature or is held there by external frost accumulation. The condensed refrigerant then flows back to the defrost storage chamber. During this time the normal refrigeration process is supplying additional liquid refrigerant to make up for that which does not condense in the evaporators and is carried out to the absorber by the gas flow. Thus substantially no refrigeration has taken place during this time because of the re-

duction in the flow of inert gas. The sensible heat in the liquid refrigerant and in the weak gas aids in the defrosting process.

Although in both illustrated embodiments an electric heater **31** is shown other methods of supplying heat such as by gas burner or a transfer system relaying heat from the generator to the pumping system may be used. The defrosting system of this invention operates with whatever heat is applied to leg or pump tube **46**. Defrosting occurs regardless of the operational status of the unit at the time of the defrosting cycle. It is very desirable, however, that the refrigerator system be operating at full imput during the defrosting cycle. This will insure continuous supply of liquid refrigerant to the defrosting system.

Having described our invention as related to the embodiments shown in the accompanying drawings, it is our 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 embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

We claim:

1. In a refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into said evaporator with said liquid refrigerant normally evaporating into said gas within the evaporator to produce refrigeration, defrosting apparatus, comprising: a conduit leading to said evaporator including a reservoir for maintaining a supply of liquid refrigerant; means for periodically heating said liquid refrigerant in the reservoir; means for expelling said heated refrigerant in the form of both liquid and gas into the evaporator for causing defrosting of said evaporator by the heat of said heated refrigerant; receiving means in said evaporator for receiving said heated liquid refrigerant to form a pool having a maximum level, said inert gas conduit outlet being located beneath said maximum level to be blocked by said pool for substantially reducing said normal evaporation during defrost ing; means for permitting restricted gas flow from said conduit into the evaporator during said blocking; and means for draining said pool at the conclusion of said heating preparatory to restoring said normal evaporation.

2. In a refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into said evaporator with said liquid refrigerant normally evaporating into said gas within the evaporator to produce refrigeration while said liquid refrigerant is flowing from one level downstream in said system, defrosting apparatus, comprising: a conduit extending from said one level to a lower level and receiving liquid refrigerant at said lower level including a reservoir for maintaining a supply of liquid refrigerant; means for periodically heating said liquid refrigerant in the reservoir; means for expelling said heated refrigerant in the form of both liquid and gas into the evaporator for causing defrosting of said evaporator by the heat of said heated refrigerant, receiving means in said evaporator for receiving said heated liquid refrigerant to form a pool having a maximum level, said inert gas conduit outlet being located beneath said maximum level to be blocked by said pool for substantially reducing said normal evaporation during defrosting; means for permitting restricted gas flow from said conduit into the evaporator during said blocking; and means for draining said pool at the conclusion of said heating preparatory to restoring said normal evaporation.

3. In a refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptiying into said evaporator with said liquid refrigerant normally evaporating into said gas within the evaporator to produce refrigeration while said liquid refrigerant is flowing from one level downstream in said system, defrosting apparatus, comprising: a conduit extending from said one level to a lower level and receiving liquid refrigerant at said lower level, the conduit including a depending loop forming a reservoir having a lower portion in which liquid refrigerant is maintained; means forming an accumulator chamber in said conduit between said lower level and said lower portion, the chamber thereby having an inlet receiving liquid from said lower level and an outlet leading to said reservoir lower portion; an outlet conduit leading from said chamber to said system at an area downstream from said lower level for conveying liquid refrigerant back to said system; means for periodically heating said liquid refrigerant in the loop at an area between said lower portion and said one level simultaneously to heat the liquid and expel the heated liquid refrigerant into the evaporator at said one level for defrosting the same; receiving means in said evaporator for receiving said heated liquid refrigerant to form a pool having a maximum level, said inert gas conduit outlet being located beneath said maximum level to be blocked by said pool for substantially reducing said normal evaporation during defrosting; means for permitting restricted gas flow from said conduit into the evaporator during said blocking; and means for draining said pool at the conclusion of said heating preparatory to restoring said normal evaporation.

4. The apparatus of claim 3 wherein said outlet conduit has an inlet end within said chamber above the level of said chamber inlet.

5. The apparatus of claim 3 wherein said outlet conduit has an inlet end at said chamber beneath said chamber outlet.

6. In an absorption refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into the evaporator, defrosting apparatus, comprising: a conduit leading to said evaporator including a reservoir for maintaining a supply of liquid refrigerant; means for periodically heating said refrigerant in the reservoir; means for flowing said heated liquid refrigerant into the evaporator for defrosting the same; means forming a liquid seal with said flowing heated liquid refrigerant during said defrosting for blocking said inert gas outlet; and means for continuing limited flow of inert gas from said conduit into said evaporator during said blocking of said outlet.

7. In an absorption refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into the evaporator, defrosting apparatus, comprising: a conduit leading to said evaporator including a reservoir for maintaining a supply of liquid refrigerant; means for periodically heating said refrigerant in the reservoir; means for expelling said heated liquid refrigerant into the evaporator for defrosting the same; a sump for said heated liquid refrigerant communicaing with said evaporator, the outlet of the inert gas conduit being closed when the sump contains a predetermined amount of said heated liquid refrigerant and the sump including means for removing liquid therefrom subsequent to said defrosting; and means for continuing limited flow of inert gas from said conduit into said evaporator during said blocking of said outlet.

8. In an absorption refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into the evaporator, defrosting apparatus, comprising: a conduit leading to said evaporator including a reservoir for maintaining a supply of liquid refrigerant; means for periodically heating said refrigerant in the reservoir; means for expelling said heated liquid refrigerant into the evaporator for defrosting the same; and a sump within the evaporator for receiving said heated liquid, the outlet of the inert gas conduit extending into said sump to be sub-

stantially blocked by said heated liquid refrigerant in the sump when the sump contains a predetermined amount of said liquid, the gas conduit including means for conveying inert gas therefrom to the evaporator at a reduced rate when said gas outlet is thereby blocked by said liquid and the sump including means for removing liquid therefrom subsequent to said defrosting

9. In an absorption refrigeration system including an evaporator having an inlet for liquid refrigerant and a conduit for inert gas having an outlet emptying into the evaporator, the gas thereby normally flowing into the evaporator and the refrigerant evaporating into the gas to provide refrigeration while the refrigerant flows from one level downstream in said system, defrosting apparatus, comprising: a conduit extending from said one level to a lower level and receiving liquid refrigerant at said lower level, the conduit including a depending loop forming a reservoir having a lower portion in which liquid refrigerant is maintained; means forming an accumulator chamber in said conduit between said lower level and said lower portion, an outlet conduit leading from said chamber to said system at an area downstream from said lower level for conveying liquid refrigerant back to said system; means for periodically heating said liquid refrigerant in the loop at an area between said lower portion and said one level simultaneously to heat the liquid and expel the heated liquid refrigerant into the evaporator at said one level for defrosting the same; and a sump within the evaporator for receiving said heated liquid refrigerant, the outlet of the inert gas conduit extending into said sump to be substantially blocked thereby when the sump contains a predetermined amount of said liquid, the gas conduit including means for conveying inert gas therefrom to the evaporator at a reduced rate when said gas outlet is thereby blocked by said liquid and the sump including means for removing liquid therefrom subsequent to said defrosting.

10. In an absorption refrigeration system including an evaporator, a conduit for liquid refrigerant having an outlet emptying into the evaporator and a conduit for inert gas having an outlet emptying into the evaporator, defrosting apparatus, comprising: a conduit for hot liquid refrigerant having an outlet emptying into the evaporator during a defrost cycle for defrosting the evaporator; means within said evaporator forming a liquid seal with said hot liquid refrigerant blocking said inert gas outlet during said defrosting; and means for continuing limited flow of inert gas from said conduit into said evaporator during said blocking of said outlet.

11. In an absorption refrigeration system including an evaporator, a conduit for liquid refrigerant having an outlet emptying into the evaporator and a conduit for inert gas having an outlet emptying into the evaporator, defrosting apparatus, comprising: a conduit for hot liquid refrigerant having an outlet emptying into the evaporator during a defrost cycle for aid in defrosting the evaporator; a sump in the evaporator receiving said hot liquid refrigerant, said outlet of the inert gas conduit extending into said sump to be substantially blocked thereby when the sump contains a predetermined amount of said liquid; and means forming a second outlet from said gas conduit emptying into the evaporator at all times.

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