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ABSORPTION REFRIGERATION

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Fig. 1.

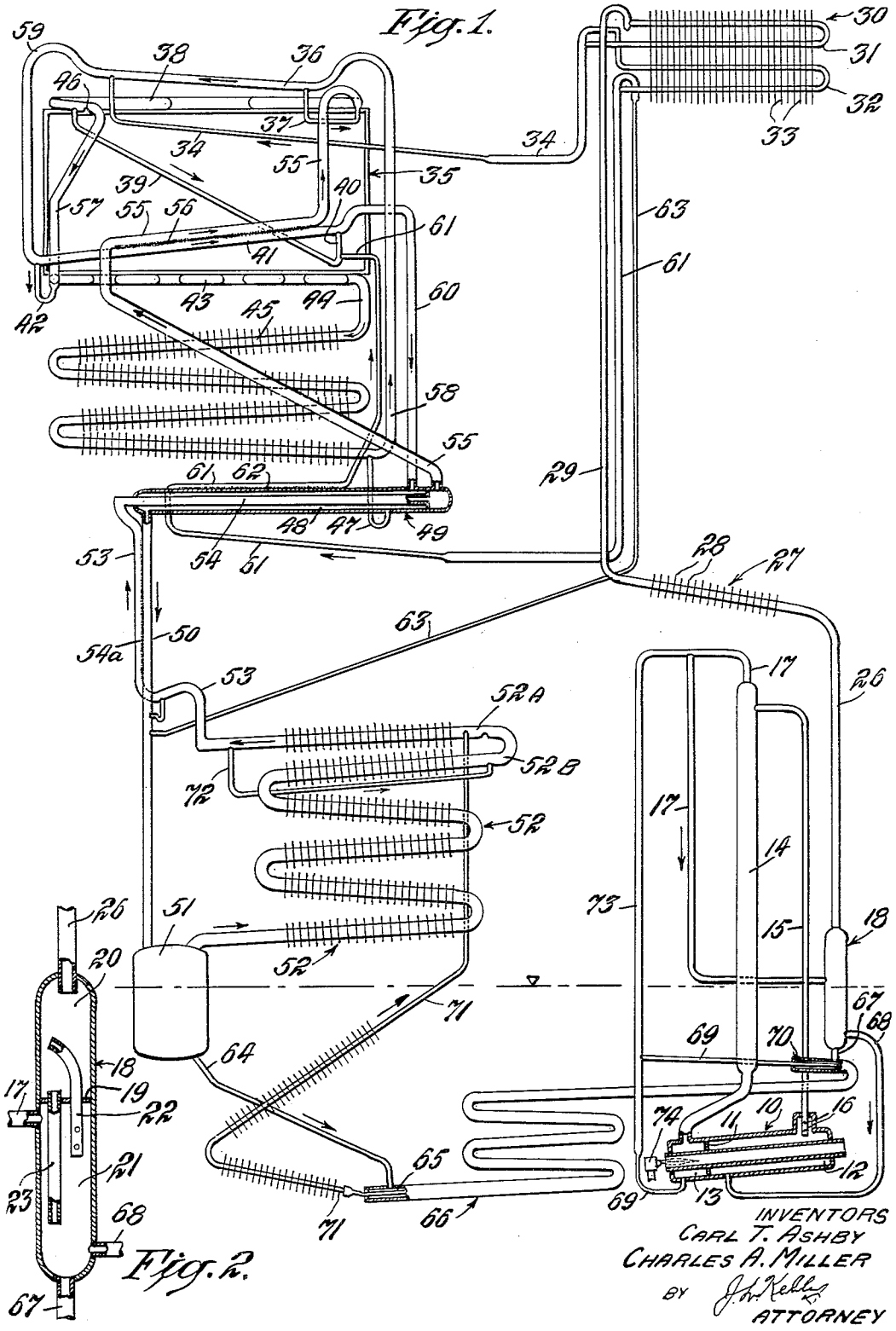


Fig. 2.

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ABSORPTION REFRIGERATION

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3 Claims. (Cl. 62—119.5)

This invention relates to the art of refrigeration and particularly to absorption refrigerating systems of the three fluid or uniform pressure type wherein an inert gas is used to maintain an equal pressure throughout the system. More particularly this invention relates to refrigerating systems of the above type wherein two or more liquid drains in the form of liquid traps are used for flowing liquid refrigerant from the condenser to the evaporator of such system and wherein the condenser is vented to an inert gas circuit.

When two or more condenser drains are used on a refrigerating system of the above type it is necessary that the drain from the last part of the condenser, that is the part of the condenser that is last to receive refrigerant vapor from the generator, always contains liquid refrigerant when the system is operating in normal or below normal room temperatures even though liquid refrigerant is not supplied to this drain by the condenser during such normal operation. With a refrigerating system wherein inert gas is used to maintain a uniform pressure, should the drain from the last part of the condenser go dry it may cause a short circuit around the inert gas circuit. Then, when hot room temperature conditions are encountered, and refrigerant vapor is supplied to the last part of the condenser and is condensed therein, a second gas circuit may be set up through the drain which will cause the liquid refrigerant flowing thereinto to evaporate and diffuse into the inert gas in the drain and thus prevent such liquid refrigerant from ever reaching the evaporator.

It is therefore an object of our invention to provide means for preventing short circuiting of inert gas in refrigerating systems of the uniform pressure type.

It is a further object of our invention to provide improved means for precooling liquid refrigerant en route from the condenser to the evaporator, and for precooling inert gas en route from the absorber to the evaporator of a refrigerating system of the above type.

Further objects and advantages of our invention will be apparent from the following description considered in connection with the accompanying drawing in which:

Fig. 1 is a more or less schematic illustration of a refrigerating apparatus embodying our invention; and

Fig. 2 is a detail section of a part of the apparatus illustrated in Fig. 1.

Referring to the drawing, reference character **10** designates a generator divided by a partition **11** into a circulating chamber **12** and a weak liquid chamber **13**. A standpipe **14** extends upward from chamber **13**, and a vapor lift conduit **15** extends from within pump chamber **12** to the upper part of standpipe **14**. The lower end of conduit **15** projects below the level of liquid maintained within chamber **12** and is provided with apertures **16** near its lower end. A conduit **17** connects the upper end of standpipe **14** to an analyzer **18**. A partition **19** divides the analyzer into an upper chamber **20** and a lower chamber **21**. A vapor lift conduit **22** and a drain **23** connect the analyzer chambers **20** and **21**.

A conduit **26** communicates with the upper part of chamber **20** and leads upward to a rectifier **27** which may comprise a section of conduit provided with air cooled fins **28**. A conduit **29** connects the rectifier to the upper part of a condenser **30**. The condenser is formed of an upper section **31** and a lower section **32**, each of which sections is provided with air cooled fins **33**.

A conduit **34**, in the form of a liquid trap, connects section **31** of the condenser to an evaporative precooler **36**, and the precooler is connected by a liquid trap **37** to an upper section **38** of an evaporator. The upper section of the evaporator is connected by a conduit **39**, having a liquid trap **40** in the lower portion thereof, to one end of a second evaporative precooler **41** and the opposite end of this evaporative precooler is connected by a liquid trap **42** to one end of an intermediate section **43** of the evaporator. The opposite end of the intermediate section of the evaporator is connected by a conduit **44** to the upper part of a lower section **45** of the evaporator. The liquid and gas outlet end of section **38** of the evaporator is provided with a dam **46**.

The upper and intermediate sections, **38** and **43**, of the evaporator are formed as flat coils and are placed in good thermal contact with the top and bottom, respectively, of a freezing chamber **35** located within a refrigerator cabinet (not shown), and the lower section **45** of the evaporator is located in a food storage compartment of such cabinet. The top wall of the freezing chamber and the upper evaporator coil **38** are inclined slightly for downward flow of liquid refrigerant therethrough from right to left, as viewed in the drawing. However, the bottom wall of the freezing chamber, which may be termed a freezing shelf or plate in that it is adapted to support ice trays or the like for freezing the contents thereof, should be substantially level and some provision should be made for downward flow of liquid refrigerant through the attached section **43** of the evaporator. This section may, for example, be formed as a tapered coil with a flat plate secured thereto similar to that described and claimed in application Serial No. 164,969 of Charles A. Miller, filed May 29, 1950.

The lowermost part of section **45** of the evaporator is connected by a liquid trap **47** to an outer passage **48** of a gas heat exchanger **49**, and the opposite end of this passage is connected by a conduit **50** and an absorber vessel **51** to the lower part of an air-cooled absorber **52**. The upper part of the absorber is connected by a conduit **53** to an inner passage **54** of the gas heat exchanger. As shown, portions of conduits **50** and **53** are placed in good thermal contact with each other, as by a weld **54a**.

A conduit **55** connects the inner passage of the gas heat exchanger to the gas inlet end of section **38** of the evaporator. As shown, a portion of conduit **55** is placed in thermal contact, as by a weld **56**, with a portion of the evaporative precooler **41**. The gas outlet end of section **38** of the evaporator is connected by a conduit **57** to the gas inlet end of section **43** of the evaporator, and as stated, the gas outlet end of section **43** is connected by conduit **44** to the upper portion of section **45** of the evaporator. The lower portion of section **45** is connected by a conduit **58** to one end of the evaporative precooler **36**, and the opposite end of this evaporative precooler is connected by a conduit **59** to the gas inlet end of the evaporative precooler **41**. The opposite end of this evaporative precooler is connected by a conduit **60** to the outer passage **48** of the gas heat exchanger.

The lower section **32** of the condenser is connected by a conduit **61** to the liquid trap **40** at the lower end of conduit **39**. For reasons to be described hereinafter, conduit **61** is in the form of a liquid trap which receives liquid refrigerant from conduit **39** as well as from the

lower section of the condenser. A portion of conduit **61** is placed in thermal contact as by a weld **62**, with the outer passage **48** of the gas heat exchanger. A vent conduit **63** connects the outlet of section **32** of the condenser to the gas line **50** between the outer passage of the gas heat exchanger and the absorber vessel **51**.

A conduit **64** connects the lower portion of the absorber vessel **51** with one end of an outer passage **65** of a liquid heat exchanger **66**, and the opposite end of such passage is connected by a conduit **67** to the lower chamber **21** of the analyzer. A conduit **68** connects the lower chamber of the analyzer to chamber **12** of the generator, and a conduit **69** connects chamber **13** of the generator with one end of an inner passage **70** of the liquid heat exchanger, the opposite end of which passage is connected by a conduit **71** to an upper portion **52A** of the absorber. A conduit **72** connects the liquid outlet end of section **52A** of the absorber with the next lower section **52B** thereof. The upper portion of conduit **69** is connected by vent conduit **73** to the upper end of conduit **17** leading from the standpipe **14**. The generator may be heated by any suitable heating element, as by a gas burner **74**.

The operation of the apparatus incorporating our invention is as follows:

The generator **10** is filled with an absorption liquid, for instance water, in which is dissolved a suitable refrigerant, as ammonia. The portion of the system not occupied by the ammonia-water solution is originally charged with a gas inert with respect to ammonia and insoluble in water. This gas is preferably hydrogen.

Application of heat to the generator **10** causes ammonia to be expelled from solution in the form of vapor. This vapor collects in the upper part of chamber **12** and passes through the apertures **16** in conduit **15** and entrains slugs of liquid within the conduit and lifts them to the upper part of standpipe **14** in well known manner. Ammonia vapor driven from the solution contained in chamber **13** passes upward through the standpipe **14**. Some water vapor necessarily passes along with the ammonia vapor and the mixture of ammonia and water vapors from both chambers **12** and **13** passes from the upper part of standpipe **14** through conduit **17** to the lower chamber **21** of the analyzer.

Chamber **21** of the analyzer is supplied with enriched absorption liquid from the absorber, that is absorption liquid in which refrigerant gas has been absorbed, and the vapor in chamber **21** passes through the apertures in vapor lift conduit **22** and lifts a portion of the enriched liquid through conduit **22** to the upper chamber **20**, in a manner similar to that described in connection with vapor lift conduit **15**. The hot vapor mixture of ammonia and water is brought into intimate contact with the cooler strong absorption liquid during the passage through conduit **22** so that water vapor which accompanies the ammonia vapor from the generator is condensed and returns with the solution through drain conduit **23** to the lower chamber **21**. The enriched absorption solution flows from the analyzer through conduit **68** into chamber **12** of the generator, and the refrigerant vapor passes upward through conduit **26** to the rectifier **27**. In the rectifier the vapor is cooled sufficiently to condense most of the remaining water vapor and this condensate drains back through conduit **26** to the analyzer. The ammonia vapor passes from the rectifier through conduit **29** to the upper section **31** of the condenser.

Assuming that the ambient temperature is normal, say about 70° F., then all ammonia vapor supplied to section **31** of the condenser is condensed therein and the liquid ammonia flows therefrom through conduit **34** to the liquid inlet end of the evaporative precooler **36**. A small portion of this liquid refrigerant evaporates and diffuses into inert gas flowing through the evaporative precooler, which evaporation results in absorption of heat from the remaining liquid whereby the remaining liquid is cooled and flows through trap **37** into section **38** of the evaporator. In this section of the evaporator the liquid refrigerant flows in concurrent relation with weak inert gas entering the evaporator through conduit **55**. Part of the liquid refrigerant evaporates and diffuses into the inert gas, which evaporation results in absorption of heat from the freezing chamber **35**. Ordinarily, liquid refrigerant would flow out of section **38** through conduit **57** into the intermediate section **43** of the evaporator.

With our invention however, the dam **46** prevents the liquid refrigerant from flowing into conduit **57** but sends such refrigerant through conduit **39** and trap **40** into the second evaporative precooler **41**. In this precooler, the liquid refrigerant and inert gas flow in countercurrent relation and again a small amount of liquid refrigerant evaporates and diffuses into the inert gas, which evaporation results in absorption of heat from the remaining liquid refrigerant and from inert gas flowing through conduit **55**. From the second evaporative precooler, liquid refrigerant flows through trap **42** into the liquid inlet end of section **43** of the evaporator. In section **43** of the evaporator, the liquid refrigerant and inert gas flow in concurrent relation and part of the liquid refrigerant evaporates and diffuses into the inert gas, which evaporation results in absorption of heat from the bottom or freezing plate of chamber **35**. The remaining liquid refrigerant and the partially enriched inert gas flow from section **43** of the evaporator through conduit **44** into the upper portion of section **45** of the evaporator.

In section **45**, the liquid refrigerant evaporates and diffuses into the inert gas, which evaporation results in absorption of heat from the food compartment (not shown) of the refrigerator in which this section of the evaporator is located. Any excess liquid refrigerant that passes through section **45** of the evaporator flows therefrom through trap **47** into the outer passage **48** of the gas heat exchanger, and the enriched inert gas flows from the lower portion of this section of the evaporator through conduit **58** into and through the evaporative precooler **36**. From the opposite end of the precooler **36**, the enriched inert gas flows through conduit **59** into and through the second precooler **41**, and from there this enriched inert gas flows through conduit **60** into the outer passage **48** of the gas heat exchanger.

From the outer passage of the gas heat exchanger the enriched inert gas flows through conduit **50** into the absorber vessel **51**, and from there this rich inert gas flows into the lower portion of the absorber **52** wherein the gas is brought into intimate contact with weak absorption liquid flowing downward through the absorber in counter-flow relation with the upward flowing inert gas. In the absorber, the ammonia is absorbed by the weak absorption liquid, while the hydrogen gas passes from the upper part of the absorber through conduit **53** into the inner passage **54** of the gas heat exchanger. In passing through the vertical portion of conduit **53** the relatively warm inert gas gives up heat to the relatively cold inert gas flowing through conduit **50**, and in passing through the inner passage of the gas heat exchanger, the inert gas again gives up heat to the cold inert gas flowing through the outer passage. From the inner passage **54** of the gas heat exchanger, the inert gas flows through conduit **55** into the gas inlet end of section **38** of the evaporator. In passing through conduit **55** this inert gas in further cooled by transfer of heat therefrom to the second evaporator precooler **41**.

From the lower portion of the absorber, the strong absorption solution flows into the absorber vessel **51**, and from there it passes through conduit **64**, the outer passage of the liquid heat exchanger and conduit **67** into the analyzer, wherein the strong solution is brought into intimate contact with refrigerant vapor from the generator

and flows therefrom through conduit **68** into chamber **12** of the generator, as explained above. Weak absorption liquid flows from chamber **13** of the generator through conduit **69**, the inner passage of the liquid heat exchanger and conduit **71** into section **52A** of the absorber. The weak absorption liquid flows downward in section **52A** in concurrent relation with inert gas and forces the inert gas into conduit **53** thereby initiating and maintaining the flow of inert gas in the proper direction in the inert gas circuit. From section **52A**, the absorption liquid flows through conduit **62** into section **52B**, and from there, the absorption liquid flows downward through the remainder of the absorber in counter flow relation with the upwardly flowing inert gas, as explained above.

Assuming now that the ambient temperature has risen to a point, say 90 to 100° F., such that the first section **31** of the condenser is no longer capable of condensing all refrigerant vapor that is supplied thereto by the generator. Under these conditions refrigerant vapor will pass from the outlet of section **31** into section **32** of the condenser. Except for small quantities of inert gas that may find their way into the generator-condenser side of the system and be vented therefrom through section **32** of the condenser and through vent conduit **63** into the active gas circuit, the fluid in section **32** of the condenser and in vent conduit **63** will, under normal operating conditions, be more or less dormant and will consist of inert gas containing a small amount of refrigerant vapor. Now then, with a substantial flow of refrigerant vapor into section **32** of the condenser, the dormant gas mixture contained therein will be forced therefrom through the vent **63** into the active gas circuit thereby raising the total pressure in the system with the result that refrigerant vapor will be condensed in section **32** of the condenser and flow therefrom through circuit **61** and trap **40** into the evaporative precooler **41**, as liquid refrigerant.

With our invention, by having conduit **39** arranged to discharge liquid refrigerant through trap **40** into the precooler **41**, it is always assured that the liquid trap in conduit **61** will be filled with liquid refrigerant before such refrigerant can overflow from trap **40** into the precooler. This is so even though, under normal room temperature conditions, no liquid refrigerant is discharged into conduit **61** from section **32** of the condenser. Otherwise, if liquid refrigerant be discharged through conduit **57** from section **38** into section **43** of the evaporator, which heretofore has been the practice, the liquid trap in conduit **61** may, under normal room temperature conditions, be void of liquid refrigerant. If the liquid trap in conduit **61** does go dry, a short circuit will be established around the main gas circuit and when hot room temperature conditions are encountered the short circuit may become a secondary gas circuit in which all of the liquid refrigerant that flows into conduit **61** from section **32** of the condenser will evaporate and diffuse into the inert gas and thus prevent such refrigerant from ever reaching the precooler **41** and/or the evaporator section **43**. With our invention, however, the liquid trap in conduit **61** is always filled with liquid and, under hot room temperature conditions, liquid refrigerant will always flow from section **32** of the condenser through conduit **61**, trap **40**, precooler **41** and trap **42** into section **43** of the evaporator. The operation of the system under hot room conditions is otherwise the same as that described above in connection with the operation under normal room temperatures.

While we have illustrated and described a more or less specific embodiment of our invention, it is to be understood that variations thereof fall within its scope as set forth in the following claims.

What is claimed is:

1. A refrigerating system including a generator, a condenser including an upper and a lower section, an evaporator including an upper and a lower section, an absorber and conduits interconnecting said elements and forming therewith a first circuit for flow of refrigerating medium, a second circuit for flow of inert pressure equalizing gas and a third circuit for flow of absorption solution, said second circuit being connected between said evaporator and said absorber in a manner that inert gas weak in refrigerant from the absorber flows first through the upper section of the evaporator and then through the lower section thereof whereby said upper section of the evaporator operates at a lower temperature than the lower section, and said conduits including a first conduit connecting the upper section of the condenser to the upper section of the evaporator, a second conduit formed with a liquid trap therein connecting the lower section of the condenser to the lower section of the evaporator, and a third conduit connecting the upper and lower sections of the evaporator and having a portion thereon in open communication with said second conduit at a point below the connection of the second conduit with the second evaporator for discharging liquid refrigerant into said liquid trap prior to discharge of liquid refrigerant into said second evaporator.

2. A refrigerating system as set forth in claim 1 in which each of said first and second conduits is formed with an evaporative precooler therein for precooling liquid refrigerant flowing from the upper and lower sections of the condenser to the upper and lower sections of the evaporator, respectively.

3. A refrigerating system as set forth in claim 2 in which the evaporative precooler in said first conduit is connected to the inert gas circuit in a manner so as to receive inert gas flowing from the lower section of the evaporator toward the absorber, and in which the evaporative precooler in said second conduit is connected to the inert gas circuit and to the upper section of the evaporator in a manner so as to receive inert gas flowing from the first evaporative precooler and to receive liquid refrigerant flowing from the upper section of the evaporator.

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