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ABSORPTION REFRIGERATION

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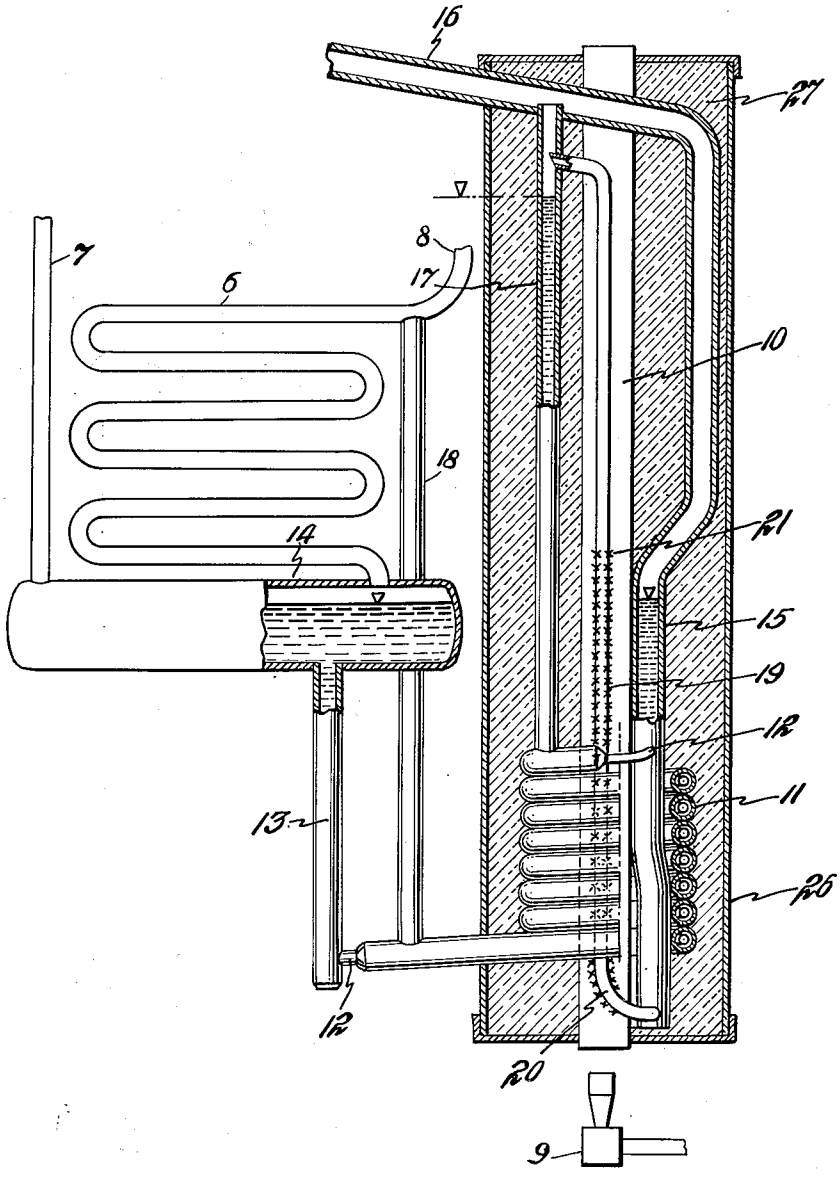

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ABSORPTION REFRIGERATION

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My invention relates to refrigeration, and more particularly to refrigeration apparatus of the absorption type in which vapor is expelled out of solution in a boiler or generator.

It has already been proposed to provide a generator for absorption refrigeration apparatus having a heating flue to which are secured in good thermal contact a boiler pipe and vapor lift tube. By providing such an arrangement in which the boiler pipe and vapor lift tube extend axially of the heating flue and in thermal contact therewith, the application of heat to the heating flue effectively heats absorption liquid in the boiler pipe to expel vapor therefrom, and also absorption liquid in the vapor lift tube to raise such liquid by vapor lift action to a higher level for gravity flow to the absorber.

In certain instances generators of the above type are connected in an absorption liquid circuit of the refrigeration apparatus in such a manner that the liquid level in the boiler pipe is a considerable distance below the liquid level maintained in the circuit by the raising of liquid by the vapor lift tube. This is especially true when absorption liquid enriched in refrigerant is supplied to the boiler pipe from an absorber and the boiler pipe freely communicates with the outlet of the absorber through a liquid heat exchanger. Under such conditions the boiler pipe, through a vertical height extending upwards from the liquid level therein to the higher liquid level to which liquid is raised by the vapor lift tube, contains no liquid.

It has been the practice heretofore to secure the boiler pipe, including the portion which does not contain liquid, in good thermal contact with the heating flue. When heating of the heating flue is accomplished by passing a suitable heating medium therethrough, such as hot combustion gases, the upper portion of the boiler pipe, above the liquid level therein, is often heated to a sufficiently high temperature to produce objectionable disturbances in the refrigeration apparatus. This occurs when the heat applied to the upper portion of the boiler pipe is such that the vapor expelled out of solution in the absorption liquid and passing therethrough becomes superheated. Such superheated or dry vapor causes objectionable disturbances in the condenser to which it passes from the boiler pipe.

Further, it is desirable that a minimum quantity of vapor of absorption liquid accompany the refrigerant vapor passing to the condenser. When excessive heating of the upper portion or vapor space of the boiler pipe takes place, this

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tends to increase the quantity of vapor of absorption liquid accompanying the refrigerant vapor passing to the condenser and increases rectification losses.

It is an object of my invention to provide an improvement for eliminating objectionable disturbances produced in refrigeration apparatus as the result of superheating of vapor in a boiler pipe of a generator, and for insuring a minimum quantity of vapor of absorption liquid accompanying the refrigerant vapor passing to the condenser. I accomplish this by thermally separating or shielding from the heating flue the upper portion of the boiler pipe above the liquid level therein. Preferably the boiler pipe is thermally separated from the heating flue through a vertical height extending upwards from the liquid level therein to the higher level at which absorption liquid is maintained by the vapor lift tube. By providing a poor heat flow path between the upper portion of the boiler pipe and the heating flue it is possible to expel from absorption liquid saturated vapor which remains in such a state in its path of flow to the condenser.

The invention, together with the above and other objects and advantages thereof, will be more fully understood upon reference to the following description and the accompanying drawing forming part of this specification, and in which the single figure illustrates more or less diagrammatically an absorption liquid circuit of absorption refrigeration apparatus including a generator embodying the invention.

In the drawing the invention is embodied in absorption refrigeration apparatus of a uniform pressure type containing an inert pressure equalizing gas. Refrigerant vapor is expelled from absorption liquid in a boiler pipe 15 by heating, and, together with vapor passing from the upper end of a vapor lift tube 19, passes through a conduit 16 to a condenser. The refrigerant vapor, such as ammonia, is liquefied in the condenser and flows into an evaporator in which the liquid refrigerant evaporates and diffuses into an inert gas, such as hydrogen, to produce a refrigerating effect. The resulting gas mixture of refrigerant and inert gas flows from the evaporator to an absorber which may be of an air cooled type including a coil 6 and an absorber vessel 14, such gas mixture entering the absorber vessel 14 through a conduit 7.

In the absorber refrigerant is absorbed from the gas mixture into absorption liquid, such as water, which is delivered thereto through a con-

duit 18, and the absorption liquid enriched in refrigerant passes into the absorber vessel 14. The inert gas is returned from the absorber to the evaporator in a path of flow including a conduit 8, and the enriched absorption liquid is conducted through a conduit 13 and inner pipe 12 of a liquid heat exchanger 11 to the generator. The weakened absorption liquid from which refrigerant vapor has been expelled is conducted from the generator through the outer passage of the liquid heat exchanger 11 and the conduit 18 to the absorber to absorb refrigerant vapor. In order to simplify the drawing, the condenser, evaporator and connections therefor have not been shown, such parts being well known and their illustration not being necessary for an understanding of my invention.

The generator comprises an open-minded heating flue 10 which may be heated in any suitable manner, as by a gas or liquid fuel burner 9, for example, which projects its flame into the lower end of the flue. The boiler pipe 15 and vapor lift pipe or tube 19 extend axially of the heating flue 10 and are secured to the outer surface of the flue in good thermal contact therewith, as by welding, for example.

The liquid heat exchanger 11 in the form of a coil is disposed concentrically about the flue pipe 10 and the upper end of the inner pipe or passage 12 thereof is connected to the boiler pipe 15 at a region below the liquid level maintained in the absorber vessel 14. The boiler pipe 15 extends upwardly from the generator and its upper extension forms the conduit 16 through which expelled vapor passes to the condenser, as previously explained.

To the lower closed end of the boiler pipe 15 is connected the lower end of the vapor lift tube 19 which is in good thermal contact with the heating flue 10 between the points 20 and 21, as by welding, for example. The upper end of the vapor lift tube 19 communicates with the upper end of a vertically disposed standpipe 17 connected at its extreme upper end to the upper end portion of the boiler pipe 15. The standpipe 17 at its lower end is connected to the outer passage of the liquid heat exchanger 11. It will be seen that the boiler member 15 and vapor lift tube 19 and heating tube 10 are disposed alongside one another and extend together as a group in an upward direction to a region at least as high as the upper end of the vapor lift tube 19.

The parts of the generator just described and the liquid heat exchanger 11 are embedded in suitable insulating material 27 contained within a metal casing or shell 26 having openings at the top and bottom thereof through which the open ends of the heating flue project.

In the operation of the refrigeration apparatus, the hot combustion gases passing through the heating flue 10 effectively heat the boiler pipe 15 in thermal contact therewith to heat the enriched absorption liquid in the latter to the boiling temperature and cause expulsion of refrigerant vapor from the absorption liquid. The principal part of the refrigerant vapor formed in the generator is expelled from absorption liquid in the boiler pipe 15, and liquid of decreasing concentration flows downwardly in the pipe 15 to the bottom closed end thereof.

From the lower end of the boiler pipe 15 absorption liquid passes into the vapor lift tube 19. The hot combustion gases passing through the heating flue 10 effectively heat the absorption liquid in the vapor lift tube 19, whereby such liquid is raised to a higher level by vapor lift action into the upper part of the standpipe 17. The standpipe 17 essentially constitutes a vessel in which a body of liquid is maintained by liquid introduced therein from the upper end of the vapor lift tube 19, the liquid surface level in the boiler member 15 being lower than the surface level of the liquid body in the standpipe 17.

Absorption liquid weak in refrigerant flows from the bottom of standpipe 17 through the outer passage of the liquid heat exchanger 11 and conduit 18 to the upper part of the absorber coil 8 which, as previously explained, may be of an air cooled type. Absorption liquid enriched in refrigerant passes from the absorber into the absorber vessel 14 and flows therefrom through the conduit 13 and inner pipe or passage 12 of the liquid heat exchanger into the boiler pipe 15.

In the drawing it will be seen that the lower end of the boiler pipe 15 extending axially of the heating flue 10 is separated and spaced from the latter. In certain instances it is desirable to provide such a thermal gap between the lower portion of the boiler pipe 15 and heating flue 10. Such a poor thermal conductive path or thermal shield may be obtained between these parts, for example, by providing an air space in the gap. In this way excessive expulsion of refrigerant vapor from absorption liquid in the lower portion of the boiler pipe 15 is prevented, thereby avoiding undesirable decrease in concentration of the absorption liquid and consequent increase in its temperature.

Since the vapor lift tube 19 is connected to the lower closed end of the boiler pipe 15 and receives absorption liquid weak in refrigerant, it is desirable to supply absorption liquid of adequate concentration to the vapor lift tube to insure sufficient expulsion of vapor in the latter to raise liquid from the boiler pipe 15 to the standpipe 17 at a normal steady rate of flow. By providing an air gap or equivalent thermal shield between the heating flue 10 and lower portion of the boiler pipe 15, as just described, the concentration of the absorption liquid passing into the lower end of the vapor lift tube 19 can be effectively controlled to assure normal pumping of liquid through the tube by vapor lift action.

In order to prevent excessive heating of the vapors passing out of the generator through the conduit 16, the upper portion of the boiler pipe 15 is thermally separated from the heating flue 10. When the boiler pipe 15 is in thermal contact with the heating flue 10 along its entire length, according to prior practice, the expelled vapors often become superheated to such a degree that the normal condensation of the vapors in other parts of the refrigeration apparatus is disturbed. Such superheating of the expelled vapors, according to prior practice, takes place in the portion of the boiler pipe 15 extending upwardly from the liquid level therein and which does not contain liquid. This is so because the hot combustion gases passing through the heating flue 10 are capable of heating the upper portion of the boiler pipe 15 to a high temperature.

In the instant embodiment of the invention the boiler pipe 15 diverges from the heating flue 10 at a region immediately above the level at which absorption liquid is maintained in the boiler pipe. At a region adjacent a side wall of the metal shell 26, the upper portion of the boiler pipe 15 extends upwardly more or less parallel to the heating flue 10. Hence, the upper portion of the boiler pipe 15, which does not contain liquid and forms a vapor space, is thermally separated

from the high temperature region of the heating flue 10 by the insulating material 27.

In this manner superheating of vapor expelled from absorption liquid is avoided and such expelled vapor in a saturated state remains saturated in its path of flow to the condenser. Moreover, the expelled vapor passes into the condenser at a temperature which is nearly within the range of the dew point of the vapor.

The conduit 16 extending upwardly from the generator to the condenser serves as an air cooled rectifier and may be provided with heat dissipating fins (not shown), as well known in the art. Any vapor of absorption liquid carried upward with the refrigerant vapor is condensed in the conduit 16 and drains back to the generator. By preventing superheating of expelled vapor in the manner just described, rectification in the conduit 16 is accomplished more effectively, thereby insuring a minimum quantity of vapor of absorption liquid accompanying the refrigerant vapor passing to the condenser.

It will now be understood that in the particular embodiment of the invention described the boiler pipe 15 freely communicates with the outlet of the absorber vessel 14 through the liquid heat exchanger 11. Hence, the boiler pipe 15 is connected to receive enriched absorption liquid and the liquid levels in the absorber vessel 14 and boiler pipe 15 are lower than the liquid level maintained in the standpipe 17 by the vapor lift tube 19. Moreover, the boiler pipe 15 and heating flue 10 are so constructed and arranged that a poor thermal conductive path is provided between the heating flue and boiler pipe through a vertical height extending approximately from the liquid level in the absorber vessel 14 to at least the liquid level maintained in the standpipe 17 by the vapor lift tube 19. Hence, while the upper portion of the boiler pipe 15 above the liquid surface level in the latter forms a part of a group of elements along with the vapor lift tube 19 and heating tube 10, such upper vapor portion of the boiler pipe 15 is thermally separated from and not heat conductively connected to the heating tube 10 as is the liquid containing portion of the boiler pipe 15.

While a single embodiment of the invention has been shown and described, it will be apparent that modifications and changes may be made without departing from the spirit and scope of the invention, as pointed out in the following claims.

What is claimed is:

1. An absorption refrigeration system having a circuit for absorption liquid comprising an absorber vessel and a generator including a vertically disposed heating flue, a boiler member comprising a first conduit, a vapor lift pump comprising a second conduit for causing flow of liquid in said circuit, said first and second conduits being in thermal contact with the outside of said heating flue and extending lengthwise of the latter, said first conduit being connected in said circuit so that the liquid level therein is substantially the same as the liquid surface level in said absorber vessel and below the liquid level maintained in said generator by said pump, and said first conduit and said heating flue being so constructed and arranged that a poor thermal conductive path is provided therebetween through a vertical height extending upwardly from approximately a level substantially the same as the liquid level in said absorber vessel to at least the liquid level maintained in said generator by said pump.

2. An absorption refrigeration system as set forth in claim 1 in which the lower end of said second conduit is in communication with the lower end of said first conduit and the bottom portion of the latter is in poor thermal conductive relation with said heating flue, whereby only an intermediate longitudinal section of said first conduit is in thermal contact with said heating flue.

3. An absorption refrigeration system having a refrigerant vapor supply line and a circuit for absorption liquid comprising a generator including a boiler member having an upper part thereof communicating with said vapor supply line, a heating flue for applying heat to said boiler member, a vapor lift tube for causing flow of liquid in said circuit, said boiler member being connected in said circuit so that the liquid level therein is lower than the liquid level maintained in said generator by said vapor lift tube, a shell within which said boiler member and heating flue and vapor lift tube are disposed, and a body of insulating material within said shell, said boiler member having a portion forming a vapor space through which expelled vapor flows in an upward direction to a level approximately at the liquid level maintained by said vapor lift tube, and said vapor forming portion of said boiler member being thermally separated from said heating flue by said insulating material through a vertical height extending upwardly approximately from the liquid level in said boiler member to at least the liquid level maintained in said generator by said vapor lift tube.

4. In an absorption refrigeration system having a refrigerant vapor supply line, a circuit for absorption liquid comprising a vapor expulsion unit including an upright heating tube adapted to be internally heated, an upright boiler member for holding a body of absorption liquid in said circuit, said boiler member communicating with the vapor supply line and extending upwardly from the liquid level of the liquid body to form a vapor space, a vapor lift tube connected in said circuit for effecting flow of liquid therein, said boiler member being connected in said circuit so that the liquid level therein is lower than the liquid level maintained by said vapor lift tube, the portion of said boiler member forming the vapor space being thermally shielded from said heating tube at least in a vertical range which is between one level substantially at the liquid level in said boiler member and a higher located level substantially at the liquid level maintained in said vapor expulsion unit by said vapor lift tube, and means providing a thermal conductive path lengthwise of said heating tube and boiler member and between exterior surfaces thereof through a vertical distance extending downwardly substantially from the liquid level in said boiler member.

5. An absorption refrigeration system having a refrigerant vapor supply line and a circuit for absorption liquid comprising a generator including a first pipe forming a boiler having an upper end thereof communicating with said vapor supply line, a second pipe forming a vapor lift, a vessel in which a liquid body is maintained by liquid introduced therein from the upper end of said vapor lift pipe, said first boiler pipe being connected in said circuit so that the liquid level therein is lower than the surface level of the liquid body maintained in said vessel, and means

including a third pipe forming a heating flue whose exterior surface is in thermal contact with said boiler and vapor lift pipes along vertically extending zones, at least a portion of the zone of thermal contact between said heating flue and said boiler pipe being at the same level as the zone of thermal contact between said heating flue and said vapor lift pipe, said last-mentioned means being effective to expel vapors from absorption liquid in said first boiler pipe and ineffective to superheat such expelled vapors flowing to the vapor supply line.

6. In an absorption refrigeration system having a refrigerant vapor supply line, an upright heating tube adapted to be internally heated, a circuit for absorption liquid including an upright boiler member for holding a body of absorption liquid in such circuit, a vapor lift tube for effecting flow of liquid in said circuit, a vessel in which a liquid body is maintained by liquid introduced therein from the upper end of said vapor lift tube, said boiler member and vapor lift tube and heating tube being disposed alongside one another and extending together as a group in an upward direction to a region at least as high as the upper end of said vapor lift tube, said boiler member being connected in said circuit so that the liquid level therein is lower than the liquid level maintained in said vessel, said boiler member having a vapor space above the liquid level therein which is in communication with the vapor supply line and through which expelled vapor flows upwardly in a path of flow extending at least to the level at which liquid is maintained in said vessel, the portion of said boiler member forming said upward path of vapor flow being a part of said group and yet thermally separated from said heating tube, and the liquid containing portion of said boiler member and said heating tube being heat conductively connected to each other in the lengthwise direction of said heating tube.

7. In an absorption refrigeration system, a circuit for absorption liquid comprising absorber structure and a generator including a boiler member for holding a body of absorption liquid in said circuit and extending above the liquid level of such body to form a vapor space through which expelled vapor flows upwardly therethrough, a heating flue adapted to be internally heated, a vapor lift tube for effecting flow of liquid in said circuit, said boiler member and vapor lift tube and heating tube being disposed alongside one another and extending together as a group in an upward direction to a region at least as high as the upper end of said vapor lift tube, said boiler member being connected in said circuit so that the liquid level therein is lower than the liquid level maintained in said generator by said vapor lift tube, the portion of said boiler member forming the vapor space being a part of said group and yet thermally separated from said heating flue at least within the limits approximately defined by the liquid level maintained in said generator by said vapor lift tube and a level substantially the same as the liquid surface level maintained in said absorber structure, and means including a longitudinal section of said heating flue for applying heat to the liquid containing portion of said boiler member within a vertical range extending upwardly substantially to the liquid level in said boiler member so as to restrict the supply of heat to the liquid containing portion in said boiler member.

8. In an absorption refrigeration system having a refrigerant vapor supply line, an upright heating tube adapted to be internally heated, a circuit for absorption liquid including an absorber vessel through which absorption liquid normally circulates during operation of the system, an upright boiler member for holding a body of absorption liquid in said circuit, a vapor lift tube for effecting flow of liquid in said circuit, said boiler member and vapor lift tube and heating tube being disposed alongside one another and extending together as a group in an upward direction to a region at least as high as the upper end of said vapor lift tube, said boiler member being connected in said circuit so that the liquid level therein is substantially the same as the liquid level maintained in said absorber vessel and lower than the liquid level maintained in said circuit by said vapor lift tube, said boiler member having a vapor space above the liquid level therein which is in communication with the vapor supply line and through which expelled vapor flows upwardly in a path of flow extending at least to the level at which liquid is maintained by said vapor lift pump, the portion of said boiler member forming said upward path of vapor flow being a part of said group and yet thermally separated from said heating tube, and the liquid containing portion of said boiler member and said heating tube being heat conductively connected to each other in the lengthwise direction of said heating tube.

9. In an absorption refrigeration system having a refrigerant vapor supply line, an upright heating tube, a circuit for absorption liquid including an upright boiler member for holding a body of absorption liquid in such circuit, a vapor lift tube for effecting flow of liquid in said circuit, said boiler member being connected in said circuit so that the liquid level therein is lower than the liquid level maintained by said vapor lift tube, said boiler member having a vapor space above the liquid level therein which is in communication with the vapor supply line and through which expelled vapor flows upwardly in a path of flow extending at least to the level at which liquid is maintained by said vapor lift pump, the portion of said boiler member forming said upward path of vapor flow being thermally separated from said heating tube, and the liquid containing portion of said boiler member being heat conductively connected to said heating tube, said boiler member in its entirety being disposed outside said heating tube and the lower part of the liquid containing portion of said boiler member being thermally separated from said heating tube.

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