June 29, 1943. P. P. ANDERSON, JR 2,323,186

REFRIGERATION

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Fig. 1.

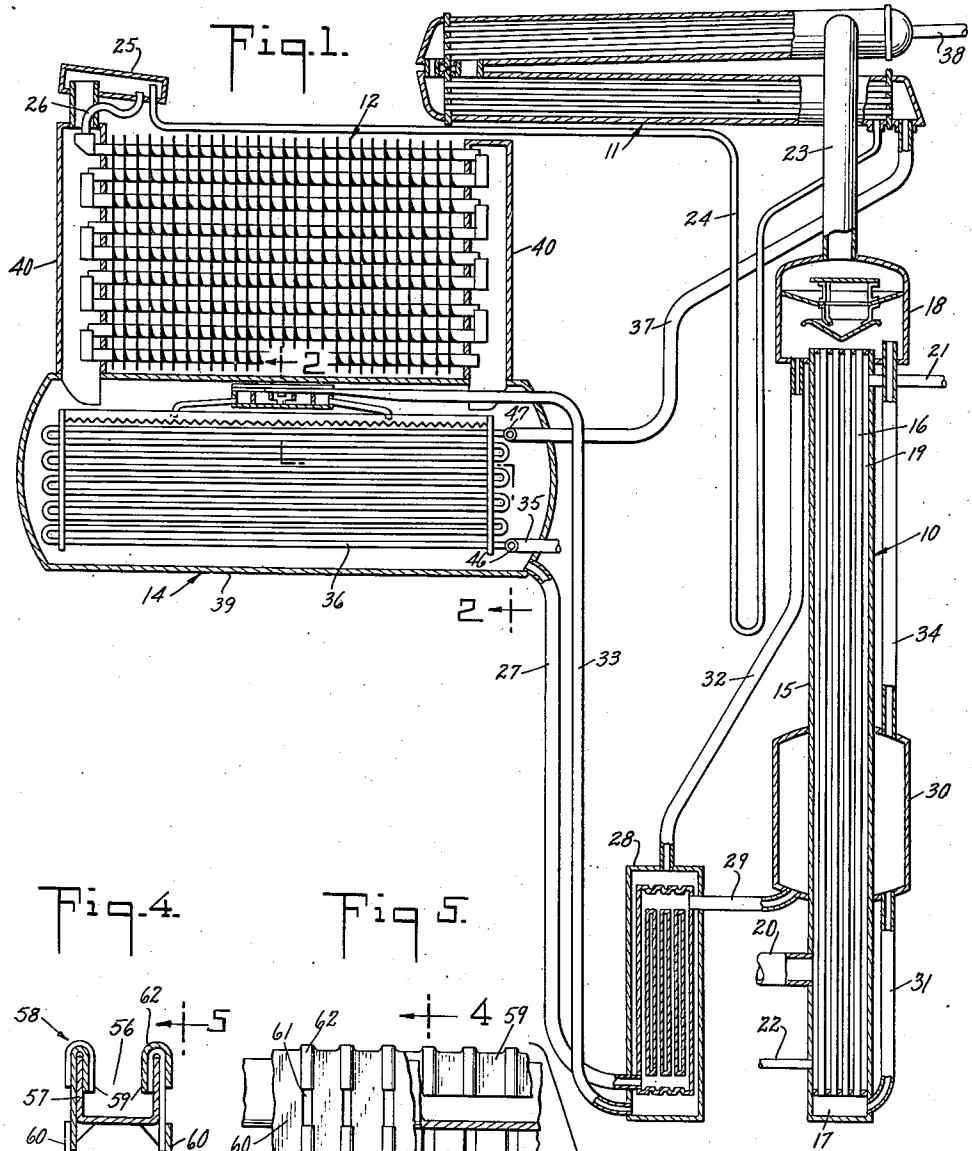


Fig. 4.

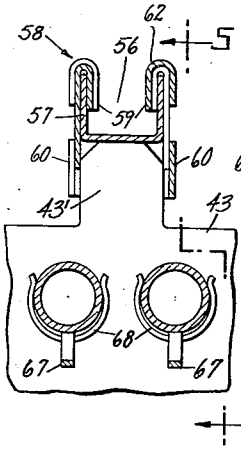
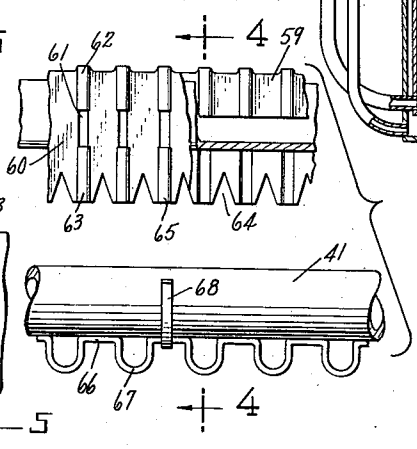


Fig. 5.



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Fig. 2.

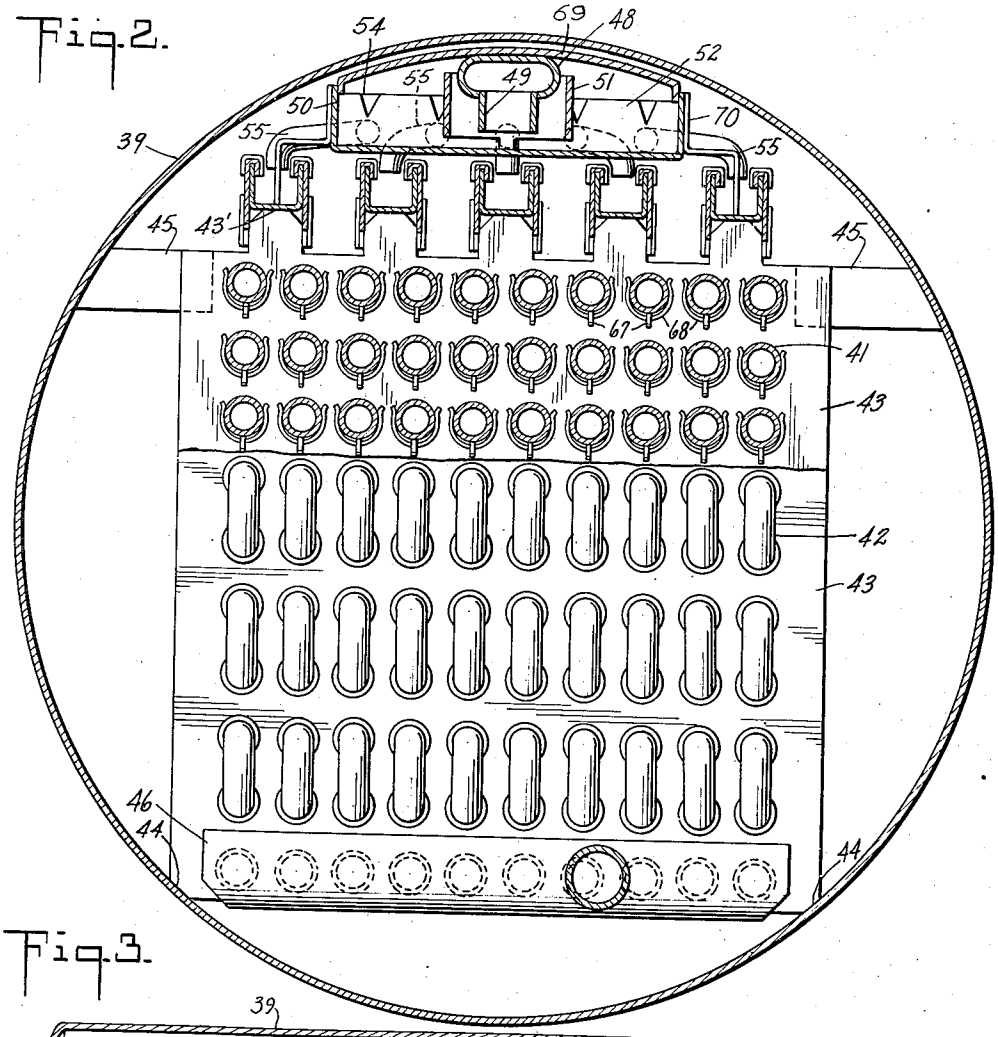
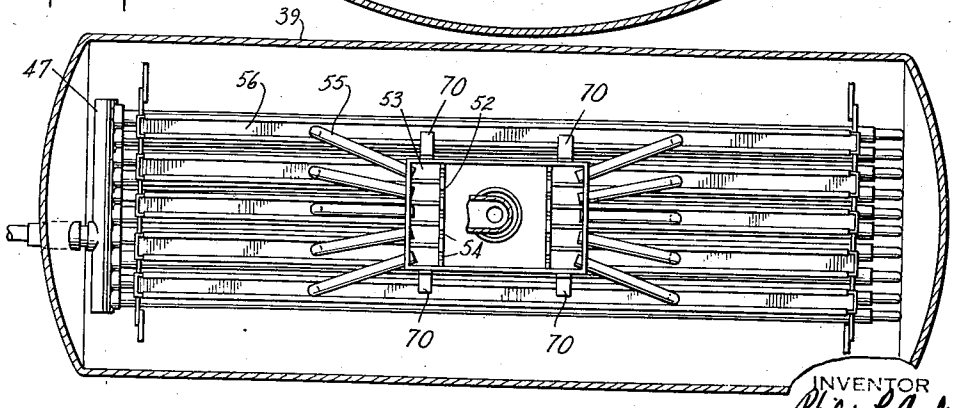


Fig. 3.



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Patented June 29, 1943 2,323,186

UNITED STATES PATENT OFFICE

2,323,186

REFRIGERATION

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Application August 26, 1941, Serial No. 408,318

8 Claims. (Cl. 62—119)

This invention relates to refrigeration, and more particularly to refrigeration apparatus of the absorption type.

It is an object of the invention to provide in apparatus of this type an improved liquid divider for subdividing liquid along a wall in such a manner that drops of liquid fall in rapid succession by gravity from spaced points at the bottom edge of the wall.

The above and other objects and advantages of the invention will be better understood from the following description and accompanying drawings forming a part of this specification, and of which:

Fig. 1 is a view more or less diagrammatically illustrating absorption refrigeration apparatus embodying the invention;

Fig. 2 is an enlarged vertical sectional view, taken at line 2—2 of Fig. 1, to illustrate more clearly the absorber of the refrigeration apparatus;

Fig. 3 is a horizontal plan view of the absorber, with the top of the shell broken away and in section, to illustrate more clearly the manner in which absorption liquid is subdivided;

Fig. 4 is an enlarged fragmentary sectional view, taken at lines 4—4 of Figs. 3 and 5, to illustrate more clearly parts of the liquid divider embodied in the absorber; and

Fig. 5 is a vertical view taken at line 5—5 of Fig. 4, partly broken away and in section, to illustrate more clearly the liquid divider embodying the invention.

Referring to Fig. 1, the present invention is embodied in two pressure absorption refrigeration apparatus like that described in application Serial No. 239,762 of A. R. Thomas and P. P. Anderson, Jr., filed November 10, 1938, now Patent No. 2,282,503, granted May 12, 1942. A system of this type operates at low pressures and includes a generator or vapor expeller 10, a condenser 11, an evaporator 12 and an absorber 14 which are interconnected in such a manner that the pressure differential in the system is maintained by liquid columns.

The disclosure in the aforementioned Thomas and Anderson application may be considered as being incorporated in this application and, if desired, reference may be made thereto for a detailed description of the refrigeration apparatus. Briefly, the generator 10 includes an outer shell 15 within which are disposed a plurality of vertical riser tubes 16 having the lower ends thereof communicating with a space 17 and the upper ends thereof extending into and above the bottom of a vessel 18. The space 19 within shell 15 and about the tubes 16 forms a steam chamber to which steam is supplied through a conduit 20 from a suitable source of supply.

The space 19 provides for full length heating of riser tubes 16 with a vent 21 provided at the upper end of shell 15 through which steam can flow into the atmosphere. Condensate formed in steam chamber 19 drains therefrom through a conduit 22 connected to the bottom part of shell 15.

The system operates at a partial vacuum and contains a water solution of refrigerant in absorption liquid, such as, for example, a water solution of lithium chloride or lithium bromide or a suitable mixture of such salts. The heating of riser tubes 16 in generator 10 by the steam causes refrigerant vapor to be expelled from absorption liquid, the expelled vapor being effective to raise liquid absorbent by gas or vapor lift action. The expelled vapor passes from the upper ends of the riser tubes 16 into the vessel 18, and thence flows through a conduit 23 into condenser 11 in which the expelled vapor is liquefied. The liquid refrigerant formed in condenser 11 flows through a U-tube 24, chamber 25 and conduit 26 into the upper part of evaporator 12. The refrigerant evaporates in evaporator 12 to produce a refrigerating or cooling effect with consequent absorption of heat from the surroundings, as from a stream of air flowing over the exterior surfaces of evaporator 12.

The refrigerant vapor formed in evaporator 12 flows therefrom to the absorber 14 in which the vapor is absorbed into absorption liquid, as will be described more fully hereinafter. The absorption liquid enriched in refrigerant is conducted from absorber 14 through conduit 27, a first passage in liquid heat exchanger 28, conduit 29, a vessel 30 and conduit 31 into space 17 of generator 10. Refrigeration vapor is expelled out of solution in generator 10 by heating, and the solution is raised by gas or vapor lift action in riser tubes 16, as explained above.

The absorption liquid in vessel 18 is deprived of refrigerant since refrigerant vapor has been expelled therefrom in generator 10. The absorption liquid in vessel 18 flows therefrom through conduit 32, a second passage in liquid heat exchanger 28, and conduit 33 into the upper part of absorber 14. This circulation of absorption liquid results from the raising of liquid in riser tubes 16, whereby the liquid can flow to absorber 14 and return from the latter to generator 10 by force of gravity. The upper part of vessel

30 and vessel 18 are connected by a conduit 34, so that the pressure in vessel 30 is equalized with the pressure in the upper part of generator 10 and condenser 11.

The absorber 14 and condenser 11 constitute heat rejecting parts of the refrigeration apparatus and are cooled by a suitable cooling medium, such as water, for example, which is conducted from a suitable source of supply through a conduit 35 to piping 36 which is vertically disposed within the absorber, whereby heat of absorption is given up to the cooling water. The cooling water flows from piping 36 through a conduit 37 to condenser 11 so that the same cooling water may be utilized to cool both condenser 11 and absorber 14. The cooling water is discharged from condenser 11 through a conduit 38.

The absorber 14 is generally like that described in application Serial No. 350,234 of A. R. Thomas and P. P. Anderson, Jr., filed August 3, 1940. Referring more particularly to Figs. 1, 2 and 3, the absorber 14 includes a cylindrical shell 39 to which is secured the lower ends of evaporator headers 40, so that vapor formed in evaporator 12 will pass through the headers into the shell 39. Within shell 39 is disposed the piping 36 formed to provide a plurality of vertical pipe banks arranged alongside of each other. Each pipe bank includes a plurality of substantially horizontal tubes 41 located one above the other and connected by bends 42. The ends of tubes 41 pass through and are secured at openings in end plates 43. The bottom corners of the end plates 43 are welded at 44 to the bottom parts of shell 39, and the top corners thereof are secured by brackets 45 to the upper parts of the shell so that a rigid support is provided for the piping 36.

The ends of the bottom tubes 41 of each pipe bank are connected to a manifold 46, as shown most clearly in Figs. 1 and 2. The top tubes are similarly connected at one end to another horizontal manifold 47, as shown most clearly in Figs. 1 and 3. The conduits 35 and 37 through which cooling water enters and leaves piping 36 pass through end openings in shell 39 and are connected to the manifolds 46 and 47, respectively. The cooling water entering through conduit 35 is distributed laterally in manifold 46 with a portion of the cooling water flowing upwardly through each vertical pipe bank. The several streams of cooling water flowing upwardly through the pipe banks come together in the top manifold 47 and the cooling water then flows through conduit 37 to condenser 11, as explained above.

The conduit 33 through which absorption liquid is introduced into absorber 14 terminates in a flattened or elliptical portion 48 disposed substantially at the center part of the shell 39. The elliptical portion 48 is closed at its extreme end and to an opening in the bottom side thereof is secured a short tubular member 49 through which entering absorption liquid passes into a liquid receptacle 50. An annular member 51 is supported in a raised position in vessel 50 to prevent splashing of liquid entering the latter.

The receptacle 50 is provided with spaced transverse walls 52 to provide smaller end compartments 53 into which liquid flows through V-shaped notches 54 in the walls 52, as shown most clearly in Fig. 2. From the smaller end compartments 53 absorption liquid passes through a plurality of pipes 55 into troughs 56 which are located alongside of each other and extend lengthwise of the shell 39. It will be noted that the pipes 55 lead from directly opposite end compartments 53 at each end of vessel 50, so that absorption liquid is supplied to the same trough 56 at regions spaced from each other. The vessel 50 is provided with a cover 69 and is supported by suitable brackets 70 secured to the outermost troughs 56, as shown most clearly in Figs. 2 and 3.

In accordance with this invention, liquid is subdivided lengthwise of the shell 39 by liquid dividers comprising the troughs 56 from which liquid is distributed and siphoned onto the upper horizontal pipes of piping 36. The troughs 56 are formed by shallow trays 57 which are U-shaped in section, as shown most clearly in Figs. 2 and 4. The trays 57 are located below the vessel 50 with the ends thereof mounted on spaced tabs 43' formed at the top edges of end plates 43. The trays 57 are secured to the tabs 43' in any suitable manner, as by welding, for example, so that the trays are rigidly supported in position.

The sidewalls of trays 57 are arranged to receive inverted U-shaped cover plates 58 having relatively short arms 59 which extend downwardly into the troughs 56 and longer arms 60 extending downwardly at the outer sides of the troughs and terminating at regions below the trays 57. The plates 58 are formed with spaced vertical slots 61 from the opposite ends of which extend grooved or fluted portions 62 and 63, respectively. The grooved portions 62 are parallel to each other and extend upwardly from the slots 61 at the outer surfaces of the tray sidewalls, across the top edges of the tray sidewalls, and downwardly into the troughs 56 to the extreme bottom edges of the short arms 59. The grooved portion 63 extend downwardly to the extreme bottom edges of the long arms 60 which are notched at 64 with the grooved portions located between the inclined side edges of adjacent notches.

The U-shaped cover plates 58 for the troughs 56 are preferably formed in a single stamping operation from flat sheet metal and then bent over a suitable rounded die to form the parallel arms 59 and 60. The plates 58 fit tightly over the sidewalls of trays 57 for the full length of the troughs 56. The grooves or fluted portions 62 are relatively shallow so that flow of liquid through the passages formed by these grooves and the adjacent surfaces of the tray sidewalls is effected by capillary siphon action.

The distance that the short arms 59 of U-shaped plates 58 extend into troughs 56 determines the height to which the liquid level must rise in the troughs before siphoning first starts by capillary action. In other words, for a given height of the short arms 59, the liquid must rise to a definite level in troughs 56 for liquid in grooves 62 to rise by capillary action in fixed paths of flow at the inner surfaces of the tray sidewalls to the extreme top edges of the latter; and, when the liquid level in the troughs reaches this definite level to effect such rise of liquid in grooves 62 to the extreme top edges of the tray sidewalls, siphoning of liquid from within the troughs takes place in fixed paths of flow formed by the grooves 62 at the inner surfaces of the tray sidewalls. After siphoning action has once been started, siphoning of liquid continues as long as the liquid level in the troughs is at or above the bottom edges of the short arms 59 of

the U-shaped plates 58. If the siphon action is broken, the liquid in troughs 56 must again rise to the definite level to cause capillary rise of liquid in the grooves 52 to the extreme top edges of the latter.

The liquid siphoned from troughs 56 flows down the surfaces of the outside arms 60 of U-shaped plates 58. By forming the shallow grooved portions 63 in alignment with the grooved portion 62 and notching the bottom edges of the long arms 60 to form teeth 65, the liquid at the outer surfaces of the tray sidewalls and surfaces of the long arms 60 is caused to flow toward a number of spaced points at which drops of liquid are formed.

The drops of liquid formed at the teeth 65 fall therefrom in rapid succession onto the top surfaces of the uppermost horizontal pipes 41 of the piping 36. The teeth 65 serve as independent horizontal drip surfaces and are spaced as closely together as possible, with the spacing being such that lateral bridging of the teeth with liquid is avoided. The drops of liquid falling by gravity from teeth 65 effect complete wetting of the exterior surfaces of the uppermost horizontal pipes 41. The uppermost horizontal pipes 41 are directly beneath the arms 60 of the U-shaped plates 58 and are preferably spaced from the bottom edges of the teeth 65 a vertical distance approximately the diameter of a drop of liquid.

To the bottom regions of all of the horizontal pipes 41, except the lowermost horizontal pipe, are secured metal strips 66 having U-shaped loops 67. The strips 66 are removably secured to the horizontal pipes 41 by spring clips 68, as shown in Figs. 4 and 5. The U-shaped loops 67 form eyelets or teeth serving as points at which drops of liquid are formed from the downwardly flowing film of liquid maintained at the exterior surfaces of the horizontal pipes 41. When the drops of liquid formed in the loops 67 become sufficiently heavy to overcome surface tension, the drops of liquid fall onto the top surfaces of the succeeding lower horizontal pipes 41. Like the teeth 65, the loops 67 are spaced as closely together as possible with the spacing being such that lateral bridging of the loops with liquid is avoided. Also, the loops 67 are preferably spaced from the top surfaces of the horizontal pipes 41 directly beneath the loops a vertical distance approximately the diameter of a drop of liquid.

While flowing over the exterior surfaces of the horizontal pipes 41, the absorption liquid absorbs refrigerant vapor passing into the shell 39 from evaporator 12 through the headers 40. The heat of absorption resulting from absorption of refrigerant vapor by the absorption liquid is given up to the cooling water which flows inside the pipes 41. The absorption liquid flows out from the bottom of shell 39 to generator 10 in a path of flow including conduit 27, as explained above.

In the type of absorber just described, it is exceedingly important that distinct drops of liquid fall in rapid succession from the sidewalls of the troughs 56 onto the horizontal pipes 41. This is readily accomplished at the troughs 56 by providing the one-piece U-shaped coverplates 58, whereby liquid is siphoned from the trays 57 onto the upper horizontal pipes 41 with the drops of liquid falling from the teeth 65 simulating a rainfall. The U-shaped coverplates 58 may be formed in a single stamping operation and then bent to form the short and longer arms 59 and 60, as explained above.

With the loops 67 causing liquid drops to be formed at the bottom sides of the horizontal pipes 41, a rainfall is simulated throughout the entire height of absorber 14, the drops of liquid always falling onto the top surfaces of all of the pipes including those at the bottom part of the absorber. Any tendency for the liquid drops to run together to produce individual streams of liquid at localized areas is avoided, whereby the entire exterior surfaces of the pipes 41 are completely wetted without reducing the capacity or the ability of the absorber to absorb refrigerant vapor into absorption liquid.

The slots 61 in the longer arms 60 of coverplates 58 are necessary when testing the liquid distributor in the presence of gas, such as air, to prevent gas binding of the capillary passages. Such slots might not be necessary when the liquid divider is embodied in absorption refrigeration apparatus like that described providing inert gas were never present. However, the slots 61 might be necessary in the event absorption liquid enters the top part of absorber 14 at a temperature above its boiling point.

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. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber, and members connecting the aforementioned parts for circulation of refrigerant and absorption liquid, structure to subdivide liquid including a liquid holder and a cover plate arranged to fit over a side wall of said holder, said plate being indented to provide relatively small passages for siphoning liquid upwardly in fixed paths of flow by capillary action from within said holder over said side wall.

2. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber, and members connecting the aforementioned parts for circulation of refrigerant and absorption liquid, structure to subdivide liquid including a liquid holder, a U-shaped cover plate having substantially parallel arms arranged to fit over a side wall of said holder, said arms being indented and adapted to overlie the inner and outer surfaces of said wall, said arm overlying the outer surface of said wall depending below the bottom of said holder and being notched to provide spaced teeth, and said cover plate being so constructed and arranged that said indentations therein form capillary passages through which liquid is siphoned upwardly in fixed paths of flow from within said holder by capillary siphon action, said spaced teeth serving as independent drip surfaces from which drops of siphoned liquid fall by gravity.

3. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber including piping having a substantially horizontal pipe section, structure to subdivide liquid to produce and maintain a liquid film on said pipe section comprising a substantially horizontal liquid holder, and a cover plate for a side wall of said holder having one arm extending within said holder and another arm overlying the outer surface of said wall and depending below the bottom of said holder, said other arm having the bottom edge thereof formed to provide spaced independent drip surfaces, and said cover plate being indented and arranged

to provide relatively small passages for siphoning liquid upwardly in fixed paths of flow from within said holder onto said other arm by capillary siphon action so that drops of siphoned liquid fall in rapid succession from said drip surfaces by gravity.

4. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber, and members connecting the aforementioned parts for circulation of refrigerant and absorption liquid, structure to subdivide liquid including a substantially horizontal liquid holder and a cover plate arranged to fit snugly over a wall of said holder, said cover plate being formed from a single sheet of metal having a short arm extending into said holder and a longer arm overlying the outside of said wall and extending below the bottom of said holder, the bottom edge of said longer arm being notched to provide spaced teeth, said longer arm being slotted at spaced intervals with grooved or fluted portions extending upwardly and downwardly from said slots, the grooved portions extending downwardly from said slots in said longer arm terminating in the region of said drip surfaces, and said grooved or fluted portions extending upwardly from said slots terminating at the bottom edge of said short arm to provide relatively narrow passages for siphoning liquid upwardly in fixed paths of flow from within said holder by capillary siphon action, said spaced teeth serving as independent drip surfaces from which drops of siphoned liquid fall by gravity.

5. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber including piping having a substantially horizontal pipe section, and members connecting the aforementioned parts for circulation of refrigerant and absorption liquid, structure to subdivide liquid including a substantially horizontal liquid holder disposed above said pipe section, and an indented cover plate having parallel arms arranged to fit over a side wall of said holder with one arm extending into said holder and another longer arm overlying the outside of said wall and depending below the bottom of said holder, the bottom edge of said longer arm being formed to provide horizontal drip surfaces spaced from said pipe section, and said cover plate being formed and arranged to provide relatively narrow passages for raising liquid upwardly in fixed paths of flow from within said holder onto said longer arm by capillary siphon action to cause drops of liquid to fall in rapid succession from said drip surfaces onto said pipe section to maintain the exterior of the latter in a completely wetted state.

6. In an absorption refrigeration system having a generator, a condenser, an evaporator and an absorber including piping having a substantially horizontal pipe section, and members connecting the aforementioned parts for circulation of refrigerant and absorption liquid, structure to subdivide liquid including a substantially horizontal liquid holder having a smooth side wall and a one-piece U-shaped cover plate arranged to fit snugly over said side wall, said cover plate being indented and arranged to provide relatively narrow passages for siphoning liquid upwardly in fixed paths of flow from within said holder by capillary siphon action, the portion of said cover plate overlying the outside of said side wall being formed to provide spaced independent drip surfaces from which drops of liquid can fall in rapid succession by gravity.

7. A liquid divider of the character described comprising a substantially horizontal liquid holder having a smooth side wall and a one-piece cover plate arranged to fit snugly over said side wall and being indented to provide relatively narrow passages to cause liquid to flow upwardly in fixed paths of flow from within said holder by capillary siphon action, the portion of said cover plate outside said holder being formed to provide a plurality of independent horizontal drip surfaces from which drops of siphoned liquid can fall in rapid succession by gravity.

8. In absorption refrigeration apparatus, a liquid divider comprising a wall at one side of which a body of liquid is adapted to be maintained, and a one-piece cover plate having an arm at each side of said wall, and said arms being formed with vertically extending grooves to form passages for raising liquid upwardly at one side of said wall in fixed paths of flow by capillary siphon action onto the other side of said wall for downflow at the other side.

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