

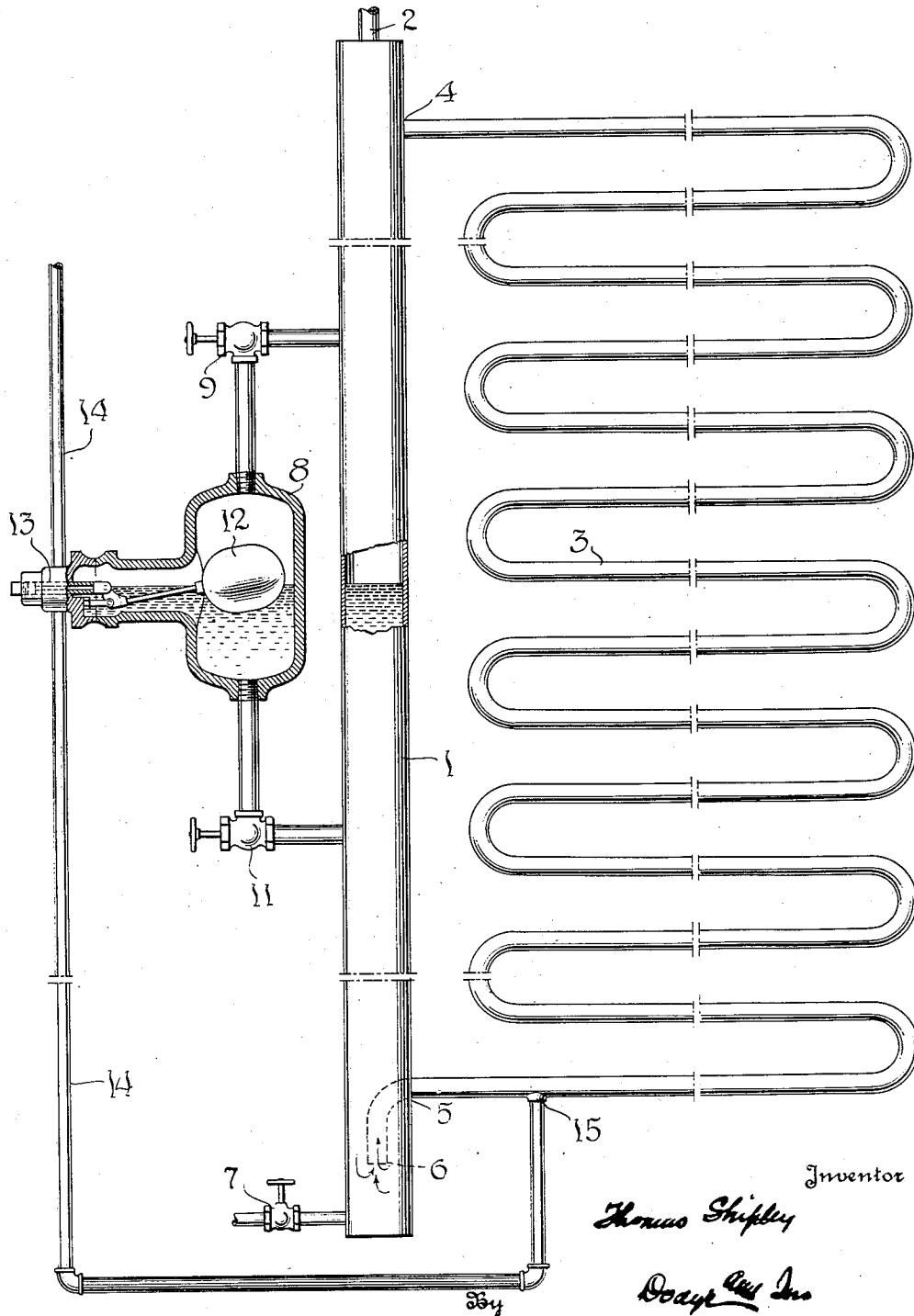
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REFRIGERATION

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REFRIGERATION

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This invention relates to a method of refrigeration and to an evaporator structure operating according to said method.

The prior art has made use of two types of evaporators, one fed by an expansion valve, and the other, the so-called flooded type, fed by a float valve. In the expansion valve type, it was the usual practice to feed the liquid refrigerant at a rate controlled by the expansion valve, to the bottom of the evaporator coils. In the flooded type it was the usual practice to feed the liquid refrigerant to a suction trap under the control of a float valve. The float valve maintained a level which was such as to insure the flooding of the evaporator with liquid refrigerant. The liquid refrigerant, entering the trap at or about condenser pressure and temperature, boiled in the trap, thus reducing its temperature to that corresponding to the suction pressure in the evaporator. The flooded type of evaporator, if kept flooded, is undoubtedly the most efficient known.

One difficulty encountered in the operation of such coils is that the circulation of liquid refrigerant from the trap through the coil and back to the trap, is very sluggish. This condition becomes more and more aggravated as the work required of the evaporator diminishes. The boiling of the liquid practically ceases and the coil fills up with a solid column of liquid. In a flat coil having horizontal passes gaseous refrigerant slowly accumulates in the various passes, reducing the effective heat transfer area. As the gaseous refrigerant accumulates a condition will be reached when upward flow of bodies of gaseous refrigerant will commence and when it commences the coalescing of the bodies of gaseous refrigerant in successive passes will soon create such a large volume of gas that this rushes rapidly up through the coil, sweeping liquid refrigerant before it and disturbing the action of the evaporator by slopping over, as the operator describes it. This slop over is likely to occur at any time, but the greatest danger is when a sudden load comes on the evaporator after it has been allowed to overfill through a period of inactivity or light load. When slop overs occur

in a flooded system substantially full of liquid there is always danger that liquid refrigerant will flow through the suction line to the compressor.

A characteristic feature of the present invention is that liquid refrigerant, at condenser pressure, or at any pressure higher than evaporator pressure, and specifically at a temperature higher than evaporator temperature, is admitted directly to the coil of a flooded system, and preferably at some point above the lowest point in that coil. It necessarily follows from the sudden reduction of pressure, that the entering refrigerant boils rapidly in cooling itself down to the temperature corresponding to the pressure in the evaporator, and develops substantial volumes of gas which set up an active circulation. This draws liquid from the bottom of the trap, circulates it upward through the coil and discharges it back into the trap. So active is this circulation that liquid refrigerant will be carried in the coils to levels substantially above the maintained liquid level in the trap because the solid column of liquid in the trap is heavier than the column of liquid and gas in the coil. It thus becomes possible to lower the liquid level in the system below the level that was heretofore possible in an ordinary flooded system. The amount of liquid which the coil will hold when it is doing little or no refrigeration work, is thus materially reduced. When operating according to this invention, the top part of the coil and the top of the trap will be free of liquid when the work on the coil is below normal and these spaces will be available as a reservoir when the work again comes on the coil and active evaporation is resumed. The excess liquid, if any, will simply fill the top pipes of the coil and flow over into the trap without danger of any liquid refrigerant being carried over to the suction of the compressor. During normal operation, reliance is placed upon the violent evaporation to carry the liquid refrigerant to the top of the evaporator.

This has several advantageous consequences. The reduction in the total amount of liquid in the evaporator, as compared to what

will be necessary in a conventional flooded system, reduces the danger of flow of liquid refrigerant to the suction line to the compressor. The rapid flow sweeps the gaseous refrigerant from the coil as rapidly as it forms, and the rapid liquid flow in contact with the coils stimulates heat transfer.

An evaporator embodying the invention is illustrated, more or less diagrammatically, in the accompanying drawing, which is an elevation with portions sectioned to show the internal construction.

In the drawing, 1 is a suction trap made in the form of a vertical stand-pipe, and 2 is a suction connection leading to the compressor, or its equivalent. A typical coil appears at 3 and represents any suitable coil structure, either single or multiple, according to the preferences of the designer. The upper end of such coil structure is connected with suction trap 1, at 4, adjacent the upper end thereof. The lower end of the coil structure is connected with the trap adjacent the lower end thereof as shown at 5. The lower end of the coil projects through the wall of the stand-pipe and makes a tight joint with it, the end of the pipe being turned downward so as to terminate below the lowest point in the bottom pass of the coil. Thus the end 6 of the coil, within the stand-pipe 1, is in effect the lowest point in the flow circuit of liquid refrigerant. 7 represents a valve controlled oil drain connection. A float chamber 8 is mounted adjacent the stand-pipe 1 and is connected therewith by pipes controlled by stop valves 9 and 11. These valves are normally open so that the level of liquid refrigerant in the chamber 8 is the same as the liquid refrigerant in the stand-pipe 1.

Mounted in the chamber 8 is a float 12, which, in response to the level of liquid refrigerant in the chamber 8, controls a balanced valve 13, closing the valve upon the rise of the float, and opening it upon the descent of the float. The valve 13 controls flow through the liquid line 14 which leads from the condenser, or other intermediate pressure vessel, not shown, to a connection 15, which is made directly with the coil 3, as contradistinguished from the trap 1, and for the best effect is somewhat above the lowest point 6 in the evaporator circuit. The reason for choosing such position for the connection is that it is desired to insure that gaseous refrigerant evolved by the entering liquid refrigerant, will flow upward through the coil 3 and not flow directly to the suction trap 1.

While the level in the chamber 8 has been described as the same as the level in the stand-pipe 1, and while this is the preferred arrangement, the important thing is that the float 12 shall act to regulate the liquid level in the stand-pipe 1 by controlling the supply of liquid refrigerant through the line

14, and any arrangement which would accomplish this result is within the scope of the present invention.

The operation is as follows:

The float 12 functions to maintain a liquid level in the stand-pipe or trap 1, materially below the point 4, at which the upper end of the coil structure is connected. The distance that it will be below is a function of the size of the pipe in the coil, the rate of heat transfer, and similar factors affecting the design. But the distance, in any event, is a substantial one.

The liquid refrigerant, passing the valve 13, is subjected to a drop in pressure from condenser pressure, or other intermediate pressure, to the pressure of evaporation in the coil 3, and considerable portion of the liquid refrigerant flashes into vapor and thus cools the remainder to evaporator temperature. It follows that at the connection 15 substantial quantities of vapor are admitted to the coil 3, and this vapor sets up what may be described as a gas-lift pumping action. The level maintained by the float 12 is so chosen that under full load conditions this gas-lift action carries liquid refrigerant through the entire height of the coil 3 and causes it to discharge back into the stand-pipe 1 at the connection 4. In this way the entire internal surface of the coil 3 is kept wet with liquid refrigerant at times when the full refrigerative effect is desired. The relatively rapid flow of liquid refrigerant upward through the coil 3 stimulates the heat transfer by sweeping away the film of forming bubbles of vapor which would otherwise act as an insulator.

The maintenance of a level in the stand-pipe 1 a substantial distance below the connection 4, reduces the quantity of liquid in the evaporator and preserves a separation space in the upper end of the stand-pipe 1. This insures the return of all liquid refrigerant to the stand-pipe and the flow of gaseous refrigerant alone through the suction line.

In certain of the claims I shall refer to the stand-pipe or trap 1 generically as a reservoir, or storage volume, which, in essence, it is, and I shall refer to the coil structure 3 as a duct of restricted cross section, which, in effect, is what it is. By the term "restricted cross section" is implied the necessity that there be such a relation between the size of the pipe in the coil, the height of the coil, and the rate of evolution of gas (which is a function of the heat transfer rate) that the gas pump action shall take place. Generally stated, the smaller the pipe the higher the liquid will be entrained by the pump action for a given temperature difference between the coil and the surrounding medium.

It is impracticable to fix positive values, but the entraining action occurs under normal conditions with pipes of the size cus-

tomarily used in commercial evaporators constructed to operate according to methods of the prior art, and no difficulty is encountered in securing the desired result.

5 What is claimed is,—

1. The method of refrigeration, which consists in establishing a closed evaporator circuit, maintaining in said circuit a definite liquid level substantially below the highest elevation in said circuit, withdrawing gaseous refrigerant from said circuit at a point adjacent the top thereof, introducing liquid refrigerant below the normal liquid level therein and at a pressure higher than evaporator pressure, and applying the resulting rapid evolution of vapor from the entering refrigerant to elevate liquid refrigerant and establish liquid circulation.

2. In an evaporator, the combination of a suction chamber; a heat absorbing coil having a lower connection with said chamber and extending thence upwardly to an upper connection with said chamber; a suction connection leading from the upper portion of such chamber; a liquid refrigerant supply connection arranged to convey liquid refrigerant at a pressure higher than suction pressure to said coil at a point above its lower connection with said chamber; and a float valve subject to the liquid level in said chamber and controlling the flow through the last-named connection.

3. In an evaporator, the combination of a suction chamber; a heat absorbing coil having a lower connection with said chamber and extending thence upwardly to an upper connection with said chamber; a suction connection leading from the upper portion of such chamber; a liquid refrigerant supply connection arranged to convey liquid refrigerant at a pressure higher than suction pressure to said coil at a point above its lower connection with said chamber; a float valve subject to the liquid level in said chamber and controlling the flow through the last-named connection, said float valve being arranged to cut off said flow as the liquid level rises and at a level substantially below the upper connection of said coil with said chamber.

4. The combination of a reservoir having a suction connection leading from its upper end; a heat absorbing evaporator coil of the multi-pass type having connections with said reservoir adjacent the upper and lower ends thereof; a connection arranged to supply liquid refrigerant at a pressure and temperature higher than that existing in said coil and to deliver said refrigerant directly to said coil; and a float valve subject to the liquid level in said reservoir and controlling the flow through the last-named connection.

5. The combination of a reservoir having a suction connection leading from its upper

end; a heat absorbing evaporator coil of the multi-pass type having connections with said reservoir adjacent the upper and lower ends thereof, the lower end of the coil being extended into the reservoir and projecting downwardly therein; a connection arranged to supply liquid refrigerant at a pressure and temperature higher than that existing in said coil and to deliver said refrigerant directly to said coil; and a float valve subject to the liquid level in said reservoir and controlling the flow through the last named connection, and serving to maintain a liquid level substantially below the upper connection between the coil and reservoir.

6. In an evaporator, the combination of a suction chamber; a heat absorbing coil having a lower connection with said chamber and extending thence upward to an upper connection with said chamber; a suction connection leading from the upper portion of such chamber; a liquid refrigerant supply connection arranged to convey liquid refrigerant, at a pressure and temperature higher than the pressure in the evaporator, directly to said coil; and automatic means subject to the liquid level in said chamber and serving to control the flow through the last named connection.

7. In an evaporator, the combination of a suction chamber; a heat absorbing coil connected at its ends with said chamber; a suction connection leading from said chamber; a liquid refrigerant supply connection arranged to convey liquid refrigerant directly to said coil at a pressure higher than suction pressure; and means for establishing a liquid level in said chamber above said liquid refrigerant supply connection and intermediate the two end connections of the coil with the suction chamber.

8. The method of refrigeration, which consists in establishing a closed evaporator circuit having upward and downward flow passes, and when in operation partially filled with liquid refrigerant; withdrawing evaporated refrigerant from the upper portion of said circuit and causing a gas-lift action to induce active circulation in the circuit by introducing liquid refrigerant into the upward flow pass at a point above the lowest point in the circuit and at a pressure substantially higher than the evaporation pressure.

9. The method of refrigeration, which consists in establishing a closed evaporator circuit having upward and downward flow passes, and when in operation partially filled with liquid refrigerant; withdrawing evaporated refrigerant from the upper portion of said circuit; condensing said evaporated refrigerant at an elevated pressure; and causing a gas-lift action to induce active circulation in the circuit by introducing the liquid refrigerant substantially at the pressure of condensation into said upward

flow pass at a point above the lowest point in said circuit.

10. The method of refrigeration, which consists in establishing a closed evaporator circuit having upward and downward flow passes, and when in operation partially filled with liquid refrigerant; withdrawing evaporated refrigerant from the upper portion of said circuit; causing a gas-lift action to induce active circulation in the circuit by introducing liquid refrigerant into the upward flow pass at a point above the lowest point in the circuit and at a pressure substantially higher than the evaporation pressure; and regulating the rate of such introduction of liquid refrigerant to maintain a definite liquid level in the circuit at a substantial distance below the highest point in the circuit.

11. The method of refrigeration, which consists in establishing a closed evaporator circuit having upward and downward flow passes, and when in operation partially filled with liquid refrigerant; withdrawing evaporated refrigerant from the upper portion of said circuit; causing a gas-lift action to induce active circulation in the circuit by introducing liquid refrigerant into the upward flow pass at a point above the lowest point in the circuit and at a pressure substantially higher than the evaporation pressure; and controlling the rate of introduction of such liquid refrigerant in response to the level of liquid refrigerant in the circuit.

12. The method of refrigeration, which consists in establishing a closed evaporator circuit having upward and downward flow passes, and when in operation partially filled with liquid refrigerant; withdrawing evaporated refrigerant from the upper portion of said circuit; and causing a gas-lift action to induce active circulation in the circuit by introducing liquid refrigerant into the upward flow pass at a point above the lowest point in the circuit and at a temperature substantially higher than the temperature in the circuit at the point of such introduction.

In testimony whereof I have signed my name to this specification.

THOMAS SHIPLEY.