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REFRIGERATION UNIT HAVING SUPERHEATED GAS FEEDBACK

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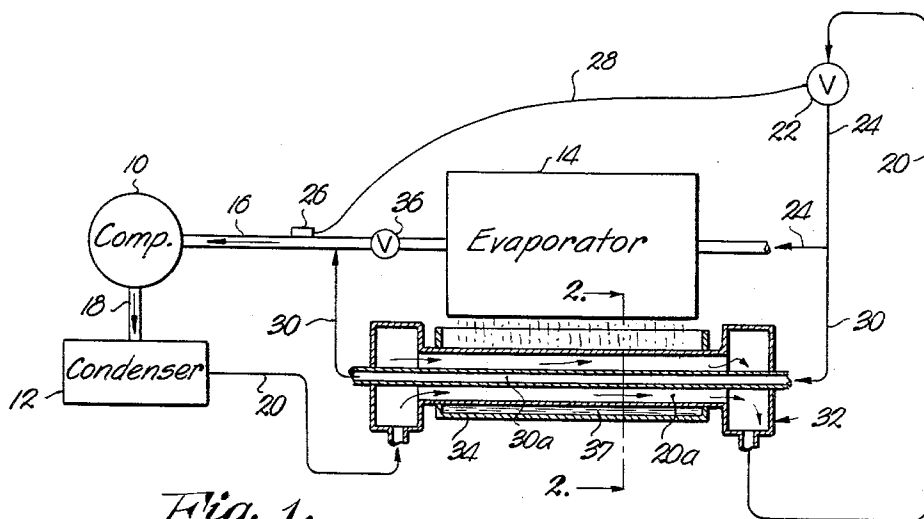


Fig. 1.

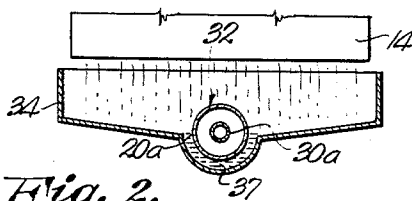


Fig. 2.

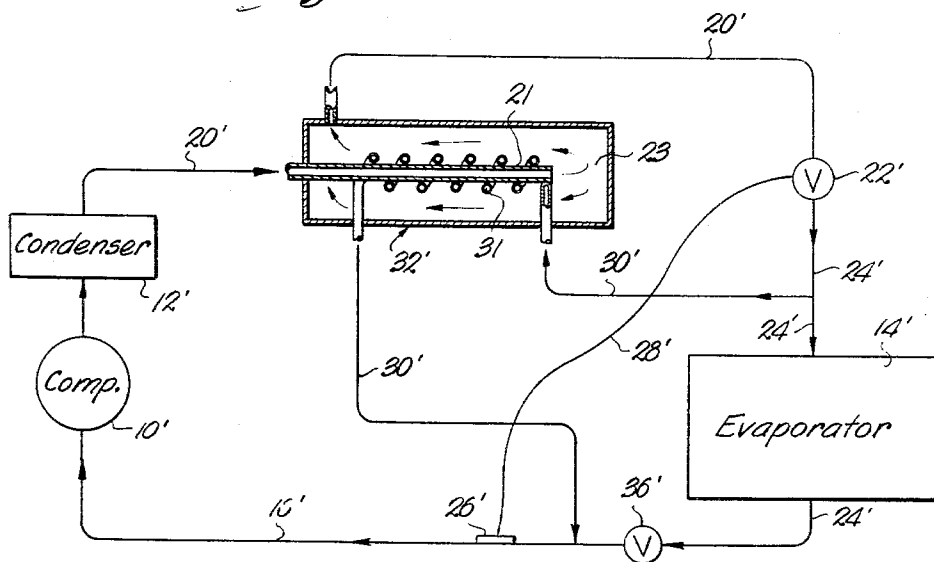


Fig. 3.

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3,214,929 REFRIGERATION UNIT HAVING SUPERHEATED GAS FEEDBACK

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This invention relates to mechanical refrigeration and has for its primary object substantial elimination of losses resulting from gas flashing in the evaporator.

Another important object of the present invention is to prevent superheating in the evaporator.

Still another important object of the instant invention is to prevent slugging of the compressor with liquid refrigerant.

A further object of my present invention is to not only accomplish all the aforementioned objects simply and inexpensively without sacrifice in performance of any of the components but, on the contrary, in a way to appreciably increase the capacity of the system at an insignificant added cost in manufacture.

For the most part, gas flashing in the evaporator has been looked upon as a necessary result which must take place in a refrigeration system as the refrigerant changes to a maximum heat-absorbing state, and little has been done to eliminate the losses which such condition produces. It has been recognized that the problem lies in the wide differential in pressure and temperature conditions on each side of the restrictor, but previous efforts to reduce the extent of temperature differential that is necessary at the reduced pressure in the evaporator so as to avoid flashing, have not been altogether satisfactory.

The difficulty lies in the fact that in any arrangement which contemplates lowering of the temperature of the refrigerant ahead of the restrictor, the approach must be such that the efficiency of the evaporator is not lowered by robbing it of the refrigerating medium necessary to absorb the maximum amount of heat in the shortest period of time possible and, at the same time, protecting the compressor by eliminating liquid at its inlet.

Accordingly, as distinguished from previous suggestions for solving the gas flash problem, it is possible through use of the present invention to lower the temperature of the refrigerant while in a liquid state ahead of the restrictor to closely approach the same temperature as it must assume at the new reduced pressure at the inlet of the evaporator, and at the same time produce a completely evaporated condition of the refrigerant in the suction line leading to the compressor.

As will hereinafter appear, the results just above explained are accomplished simply and inexpensively, and in a manner to make maximum use of the refrigerant by keeping it in a saturated liquid state for a longer period of time in the evaporator, yet produce a completely evaporated condition in the refrigerant, but without superheating, before it passes from the evaporator.

Hence, as an added precaution, in order to obtain the rather close tolerances so to speak, between complete evaporation and superheating in the evaporator, the suction line of the compressor is constantly fed with a sufficient quantity of highly superheated refrigerant to completely vaporize any liquid which might flow from the evaporator.

Maximum efficiency in my system is attained, therefore, by advantageous use of a heat exchange arrangement wherein the temperature of the entire liquid flow from the condenser is lowered before it is subjected to a restriction so that losses occasioned by gas flashing as the refrigerant passes the restriction are minimized. Then, the refrigerant emanating from the restrictor, which is appreciably cooler than the hot liquid coming from the

condenser, is divided, with a portion thereof directed to the evaporator and a portion passed to the heat exchanger. In this manner I am able to have an extremely high efficiency gain because of using as much of the cold refrigerant as may be needed or desired to cool the entire volume of hot liquid to the temperature necessary for reducing gas flash losses to a minimum. Unique also in my invention is the fact that all of the advantageous results are attained without in any manner, sacrificing other performance characteristics of the system, the net result being a substantial increase in evaporator capacity even with a reduction in the amount of refrigerant supplied to the evaporator.

Another aim of my present invention is to make advantageous use of condensate collecting on the evaporator to cool the refrigerant for the above-mentioned purposes.

Still another aim of the instant invention is to provide means, made possible through use of my new system, to control the flow of refrigerant through the evaporator, thereby controlling the temperature of the substance being cooled by the evaporator, permitting therefore, continuous operation of the compressor, and preventing the pressure at the compressor inlet from falling below a predetermined value.

In the drawing:

FIGURE 1 is a diagrammatic view, partially in section, of a refrigerating unit made in accordance with my present invention;

FIG. 2 is a cross-sectional view taken on line 2—2 of FIG. 1; and

FIG. 3 is a view similar to FIG. 1 showing a modified form of heat exchanger.

Referring first to FIGS. 1 and 2, compressor 10, condenser 12 and evaporator 14 may take any conventional form in my refrigerating system, the compressor 10 being connected with the evaporator 14 by a conduit 16 and with the condenser 12 by a line 18, in the usual manner. A restricted orifice, a capillary tube or an expansion valve may be provided in pipe 20 leading from condenser 12, an expansion valve 22 being chosen for illustration, with its outlet tube 24 feeding the evaporator 14. Bulb 26 on conduit 16 and sensitive to superheated vapor in the latter, couples with control valve 22 by virtue of a line 28, all as is well known.

The improvement of my invention includes a feedback line or bypass 30 interconnecting tube 24 and conduit 16, causing a portion of the refrigerant to return from the valve 22 to the compressor 10 without passing through the evaporator 14.

To this end, I provide a suitable heat exchanger 32, made up of a portion 20a of pipe 20 and a portion 30a of bypass 30, disposed in thermal relationship. To do this, the pipe portion 20a is simply telescoped over the bypass portion 30a, making sure that the bypass 30 connects with the tube 24 between valve 22 and evaporator 14, and with the conduit 16 between the evaporator 14 and the bulb 26.

It is also advantageous to arrange the connections such that the fluids in portions 20a and 30a of heat exchanger 32 flow in opposite directions to obtain the maximum absorption of heat by the fluid in portion 30a from the fluid in portion 20a. As a matter of fact, only highly superheated vapor should discharge from bypass 30 into conduit 16, and the sub-cooling of the liquid in portion 20a should be such as to lower its temperature to a point where very little temperature reduction takes place as a consequence of pressure reduction when the liquid is discharged into tube 24 from valve 22.

It is to be noted particularly, that all of the hot liquid from condenser 12 passes via pipe 20 through the heat exchanger 32 and is cooled by the latter before it reaches restrictor 22, and that such cooling is effected by use of

the coldest refrigerant in the system, i.e. a portion of the flow from the restrictor 22 taken off by the feedback 30.

This means then, that as the pressure drops in the liquid when it passes valve 22, there will be but a small resultant temperature drop, and the state of the liquid passing to evaporator 14 will change to its proper temperature-to-pressure ratio with very little flashing of gas, and therefore, without the substantial losses that normally occur during and because of such flashing.

For example, assume a system wherein the compressor 10 maintains a fluid pressure of 170 p.s.i.g. in pipe 20 and at such pressure the condenser 12 liquefies the fluid by lowering its temperature to 125° F. Assume also, in such hypothetical system, the nature of the refrigerant utilized is such that in its new state the liquid in tube 24 has a temperature-pressure ratio of 31° F. and 30 p.s.i.g. after flashing off of gas in tube 24 as a consequence of reaching the new state. Such gas flashing losses are reduced in the system of my invention by virtue of changing the temperature-pressure ratio in pipe 20 to closely approach 32° F. and 170 p.s.i.g. before the liquid passes valve 22. Hence, in tube 24, all that takes place is a reduction in pressure from 170 p.s.i.g. to 30 p.s.i.g. with a 1° reduction in temperature and almost no flashing of gas.

Now, it is obvious that in a system operating at the temperature-pressure ratios above selected, no added results can be attained by attempting to lower the temperature of the liquid in portion 20a below 32° F. since such will merely rob the evaporator of liquid and reduce efficiency insofar as its function of extraction of heat is concerned. It follows then that selection of a proper ratio of primary surface areas in evaporator 14 and portion 30a (which may be termed "a secondary evaporator") is highly important. In one system where the principles of the invention were tested, it was found that excellent results could be obtained where that area which is contacted by the liquid in secondary evaporator portion 30a was as little as 4% of the primary surface area of the evaporator 14.

In that same test system I was able to closely approach maximum capacity from the evaporator 14, through reduction of flash gas, by increasing the primary surface area of portion 30a to 8% of the primary surface area of the evaporator 14, and virtually eliminate flashing without a resultant, converse reduction in efficiency because of robbing evaporator 14 of refrigerant. But it may be desirable in some cases to go higher than 8%.

If the primary surface areas are of the same material, their ratios can be taken as an accurate guide even though the selection of the proper ratio depends on many variables in the over-all system such as compressor, evaporator and condenser design, all of which contribute to the capacity of the system and determine the extent of subcooling necessary to produce the desired results above enumerated. If copper is chosen for the primary surface material of one of the evaporators 14-30a and aluminum for the other, it is but necessary to consider the thermal conductivity of each in calculating the proper ratio to achieve the desired results.

It now becomes apparent that there is presented to the evaporator 14 an abundance of liquid, choke-fed thereto, so to speak, already cooled to almost maximum and completely saturated, ready to commence immediately at the evaporator inlet its function of quickly extracting the maximum amount of heat from whatever substance is placed in heat exchange relationship to evaporator 14 exteriorly thereof.

Keeping in mind then the superior heat-absorbing characteristics of a saturated liquid washing over the primary surface area of evaporator 14, as compared with a gas flowing over such surface, the present invention results in an increased volume of liquid flowing in the evaporator 14 for a longer period of time. That is, near elimination of flash gas results in the refrigerant remaining in a satu-

rated liquid condition until it has traversed a substantial portion of the primary surface area of evaporator 14, and not changing to a saturated vapor condition until it closely approaches the evaporator outlet, all as is desired in a system operating at optimum.

Ideally then, complete vaporization without superheating, taking place adjacent the evaporator outlet, will also have the added advantage of protecting the compressor 10. But, when striving for complete elimination of superheating in the evaporator 14, as the system of the instant invention is virtually capable of accomplishing, operation takes place at rather close tolerances or at that fine line between the saturated vapor temperature and superheating. Hence, in the event some liquid exists in conduit 16 at the outlet of evaporator 14 (a condition which is to be preferred, to a limited extent, over superheating) we have in the highly superheated gas emanating from bypass 30, a fluid which will, because of being dumped into conduit 16, immediately convert all such liquid to at least a saturated vapor condition. As a result, all refrigerant passing from conduit 16 to compressor 10 will be either superheated or in a saturated vapor state. At no time will compressor 10 be confronted with the damaging load, for which it is not designed, of attempting to increase the pressure of a relatively incompressible liquid refrigerant.

Turning now again to heat exchanger 32, it is manifest that there is an abundance of heat in the liquid of portion 20a to quickly boil the liquid flowing to portion 30a and furnish conduit 16 with an adequate supply of highly superheated vapor. The difficulty lies more particularly in subcooling the liquid in portion 20a to the desired temperature.

Hence, as shown in FIGS. 1 and 2, portion 20a of heat exchanger 32 may be placed in thermal relationship to condensate produced by evaporator 14 exteriorly thereof as the result of lowering the temperature of moisture laden air therearound.

The gravitational flow of such condensate traverses the directions of flow of the fluids in portions 20a and 30a, and a receptacle 34, forming a part of the heat exchanger 32, is disposed to receive the condensate. The water collects in a sump 37 of receptacle 34 within which portion 20a is immersed.

Depending again on many factors, such as the use to be made of the system and the humidity of the substance being cooled, the utilization of the condensate, to absorb some of the heat from the liquid supplied to the portion 20a, reduces the area of the primary surface of portion 30a needed to accomplish the purposes above set forth. Since the capacity of the evaporator 14 has been appreciably increased, even with a reduction in the amount of refrigerant flowing therethrough, its effectiveness in removing moisture from the air being cooled has also been increased, thereby maintaining an adequate supply of condensate in sump 37 whenever humidity conditions are such as to result in condensation on evaporator 14.

It is to be noted that when the restrictor or control 22 between pipe 20 and tube 24 takes the form of an expansion valve, the superheated vapor of bypass 30 is fed back to conduit 16 ahead of bulb 26 so that the latter, sensitive only to superheated vapors, will remain properly effective in controlling valve 22. Valve 22 will continue to open and close as the temperature of the superheated vapor in conduit 16 changes, all of which is in turn a function of variance in the load on evaporator 14, in the usual manner.

It is now possible, with those concepts of the present invention thus far explained, incorporated in the system, to control the temperature of the substance being cooled by use of a valve 36, shown in conduit 16 between bypass 30 and evaporator 14, but which may be interposed in tube 24 between evaporator 14 and bypass 30.

Valve 36 may be set to meter the flow from evaporator 14 in accordance with the temperature desired in the

compartment being cooled. An increase in the temperature of the superheated vapor passing to compressor 10 causes the thermostatic fluid in the thermostatic line 28 to expand and exert an increased pressure over the diaphragm of the thermostatic expansion valve 22, overcoming its adjusting spring, opening valve 22 and admitting more liquid refrigerant to the evaporator 14 and the heat exchanger 32.

The resulting increase in back pressure allows the spring of the valve 22 to arrest itself, forcing its diaphragm up and increasing the pressing of the incoming liquid to the heat exchanger 32 and the evaporator 14. When the pressure temperature relation of the supply 24 to evaporator 14 is raised, the load that evaporator 14 may now absorb is reduced because of the higher temperature liquid that is admitted by valve 22 to tube 24.

When valve 36 is partially closed, a reduced amount of saturated vapor is admitted to conduit 16 from the evaporator 14. However, because of constant compressor speed, a greater quantity of superheated vapor is admitted to conduit 16 by bypass 30 from the heat exchanger 32 than was the case before valve 36 was partially closed. The result is a higher vapor-temperature mixture in conduit 16 which is in contact with bulb 26. This higher temperature at bulb 26 causes the valve 22 to open and attempt to feed more liquid refrigerant to evaporator 14 and heat exchanger 32. This raises the pressure-temperature relation of the refrigerant and reduces the temperature difference between the substance being cooled by evaporator 14 and the liquid refrigerant supplied to evaporator 14. The same is true of the heat exchanger 32.

Thus, a new state of equilibrium is established between evaporator 14 and heat exchanger 32 as the result of the partial closing of valve 36. Therefore, a higher percentage of the total supply flow of valve 22 to evaporator 14 and heat exchanger 32 is now passing to the heat exchanger 32 to sub-cool the liquid flowing to valve 22 and a lesser amount is used by the evaporator 14 to satisfy its requirement to cool the substance.

For example, if 15% of the total liquid refrigerant supplied by valve 22 is being used by the heat exchanger 32, and 85% of the total is being used to cool the substance by the evaporator 14, with valve 36 fully open, then a state of equilibrium exists in these flow ratios. Now, if valve 36 is closed to reduce the flow to evaporator 14 by 25%, then only 75% of the said 85%, or 63.75% will flow through evaporator 14. But, the quantity of liquid used by the heat exchanger 32 is still the same 15% of the old equilibrium conditions (with valve 36 fully open) as it is in the new equilibrium conditions with the valve 36 one quarter closed. Thus the total flow requirement of the system is reduced to 15% plus 63.75%, or 78.75% of the fully open state of valve 36. However, the compressor 10 maintains a constant speed and maintains system refrigerant flow at 100% even though the new equilibrium only requires 78.75%; to maintain compressor flow, the supply to heat exchanger 32 now increases 21.25%. Thus the supply of superheated vapor from heat exchanger 32 to conduit 16 is increased by 142%.

Now, if in the fully open equilibrium temperatures of vapor from evaporator 14 to conduit 16 were 31° F. and superheated vapor from heat exchanger 32 to conduit 16 were 90° F., then the temperature of the mixture in contact with bulb 26 acting to control valve 22 would be (15% of 90° F.) plus (85% of 31° F.) or 39.85° F.

If the valve 22 were selected to maintain a 9° F. superheat on the combination of evaporator 14 and heat exchanger 32, then these conditions would almost exactly be met when the temperature of the supply liquid in tube 24 is 31° F., that is 31° F. plus 9° F. superheat equals a 40° F. mixture at bulb 26.

Now, if valve 36 is closed 25%, the resultant temperature of the mixture at bulb 26 is (36.25% of 90° F.) plus (63.75% of 31° F.) or 52.39° F. Therefore, valve 22 being set to maintain a 9° F. superheat on the combination of evaporator 14 and heat exchanger 32, the temperature of 52.39° F., acting on bulb 26, causes valve 22 to open, in response to the 52.39° F. mixture temperature, sufficiently to admit liquid refrigerant to tube 24 at a temperature of 43.39° F. (52.39° F. mixture minus 9° F. superheat or 43.39° F. inlet refrigerant temperature).

All of the foregoing is what happens when valve 36 is closed 25%. The following explains what happens to establish the new equilibrium:

With the new liquid supply to the combination of evaporator 14 and heat exchanger 32 being 43.39° F., the temperature difference between the substance cooled by evaporator 14 and the temperature of the liquid refrigerant is reduced by 12.39° F. (43.39° F. with valve 36 open 75% minus 31° F. with valve 36 open 100% equals 12.39° F.). Therefore, evaporator 14 must do less work.

The temperature of the liquid in pipe 20 before it reaches portion 20a is essentially unchanged because the temperature of the substance cooling the refrigerant in condenser 12 is unchanged and the compressor speed is unchanged. Therefore, the same heat in the liquid refrigerant in pipe 20 is available to the heat exchanger 32.

For illustration we will assume the temperature of liquid refrigerant in pipe 20 is 125° F. Now, after valve 36 is 25% closed and the supply refrigerant to the combination of evaporator 14 and heat exchanger 32 is raised to 43.39° F. as described above, the heat exchanger 32 temperature difference between the liquid supply from tube 24 and the temperature of the liquid in pipe 20 is also reduced by 12.39° F. However, the flow through heat exchanger 32 has increased by 142% (from 15% with valve 36 open 100% to 36.25% with valve 36 open 75%). The result is that the liquid flowing to valve 22 is further sub-cooled. The effect is the transfer of refrigeration effect to the heat exchanger 32 from evaporator 14.

Manifestly, valve 36 may be thermostatically controlled, i.e., made sensitive to the temperature change in the substance being cooled, if desired. In any event, closing of valve 36, either manually or automatically, will have no adverse effect on the moisture removing capabilities of evaporator 14. It will continue to dehumidify even if valve 36 limits the extent of temperature reduction, presenting a dry atmosphere at a desired temperature, and at the same time, supplying the sump 37 with the condensate that may be advantageously used for sub-cooling purposes as above described.

An attribute of the instant invention is another protection afforded to the system by the feedback line 30. In automotive air conditioning, for example, the r.p.m. of the compressor is directly proportional to the r.p.m. of the crankshaft of the automobile engine. Hence, at high compressor speeds, if the pressure in conduit 16 should drop below atmospheric pressure, air might well be drawn into the system past the seals of compressor 10. In the present invention, no amount of closing of valve 36 will reduce the pressure in conduit 16 sufficiently to cause any such undesirable results because the feedback line 30 is always open to provide a pressure ratio in line 18 and conduit 16 such that the pressure in the latter never drops sufficiently below atmospheric pressure to cause leaks in the compressor seals.

In FIG. 3, all components of the system similar to those previously described in connection with FIGS. 1 and 2 are designated by the same numerals, each suitably primed; hence, description thereof need not be repeated. In this case, a heat exchanger 32' has two portions 21 and 23 making up a part of pipe 20'. The tubular portion 21 is disposed within the hollow portion 23 and receives the liquid from pipe 20' for discharge into

the portion 23; the direction of flow of the liquid reverses in the portion 23, and the sub-cooled liquid passes from portion 23 directly to the valve 22'.

The evaporator portion 31 of bypass 30' is immersed in the liquid within hollow portion 23 and is in coiled engagement with tubular portion 21; and here again, the flow of the boiling refrigerant within evaporator coil 31 is generally opposite to the flow of liquid in tubular portion 21.

In all essential respects the operation of the system of FIG. 3 is the same as above described in connection with the system of FIGS. 1 and 2.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In combination:

means having a chamber for evaporation of a heat extracting medium as a consequence of heat being absorbed thereby from a substance to be cooled;
structure for drawing said medium from the chamber and exerting sufficient pressure thereon to cause it to liquefy when cooled;
a cooler for lowering the temperature of the medium emanating from said structure to liquefy the same;
a control for checking the flow of said medium from said cooler to the chamber to enable said structure to maintain enough pressure thereon to keep it liquid;
means for bypassing the chamber with a portion of the medium emanating from the control and feeding it back to the structure;
a heat exchanger placing said portion in thermal relationship to the liquid passing to the control to vaporize said portion before it returns to said structure; and
means utilizing condensate emanating from said chamber for cooling the heat exchanger.

2. In combination:

a refrigerant-receiving evaporator;
a compressor for drawing said refrigerant from the evaporator and exerting sufficient pressure thereon to cause it to liquefy when cooled;
a condenser for receiving the refrigerant from the compressor and lowering the temperature thereof to liquefy the same;
a control for checking the flow of the refrigerant from the condenser to the evaporator to enable the compressor to maintain enough pressure thereon to keep it liquid;
means dividing the refrigerant flowing from the control and being out of substantial heat exchange relationship with said evaporator for placing the refrigerant flowing to the control in thermal relationship to a portion of the refrigerant flowing from the control to vaporize said portion;
means re-admixing said vaporized portion of the refrigerant with the vaporized refrigerant emanating from the evaporator for return to the compressor; and
means placing said refrigerant flowing to the control in thermal relationship to condensate emanating from the exterior of the evaporator.

3. In combination:

a refrigerant-receiving evaporator;
a compressor for drawing said refrigerant from the evaporator and exerting sufficient pressure thereon to cause it to liquefy when cooled;
a condenser for receiving the refrigerant from the compressor and lowering the temperature thereof to liquefy the same;
a control for checking the flow of the refrigerant from the condenser to the evaporator to enable the compressor to maintain enough pressure thereon to keep it liquid;
means dividing the refrigerant flowing from the control and being out of substantial heat exchange relationship with said evaporator for placing the refrigerant

flowing to the control in thermal relationship to a portion of the refrigerant flowing from the control to vaporize said portion;

means re-admixing said vaporized portion of the refrigerant with the vaporized refrigerant emanating from the evaporator for return to the compressor;

means placing said refrigerant flowing to the control in thermal relationship to condensate emanating from the exterior of the evaporator; and

means for varying the flow of refrigerant through the evaporator.

4. Structure for reducing flash gas in the evaporator of a refrigerating system having a collector for condensate flowing from the evaporator, a compressor, a condenser and an expansion valve, there being a conduit connecting the evaporator with the compressor, a control for the valve in heat exchange relationship to the conduit, a pipe interconnecting the condenser and the valve, and a tube coupling the valve with the evaporator:

a refrigerant bypass disposed out of substantial heat exchange relationship with said evaporator, communicating with said tube and discharging into said conduit between the evaporator and said control; and
a heat exchanger in said collector and having said pipe and said bypass as a part thereof.

5. A process of cooling in a continuous cycle which comprises the steps of:

exerting sufficient pressure on a superheated refrigerant to cause it to liquefy when cooled;
lowering the temperature of the pressurized refrigerant sufficiently to liquefy the same;
restricting and thereupon decreasing the pressure of all of the liquefied refrigerant;
dividing said liquefied refrigerant after the pressure thereof has been decreased;
directing a portion of said divided refrigerant into heat exchange relationship with moisture-laden air to be cooled;
collecting the moisture removed from the air as a consequence of extraction of heat from the latter by said portion;
directing all of the liquefied refrigerant while the flow thereof is restricted into heat exchange relationship with the collection of moisture, and directing a second portion of said divided refrigerant into heat exchange relationship with all of the liquefied refrigerant while the flow thereof is restricted to sub-cool all of the latter before the pressure thereof is decreased; and

readmixing said portions after the same have extracted heat from said air and from said restricted flow of liquefied refrigerant respectively, whereby to present a superheated admixture prior to again pressurizing the same in continuation of the cycle.

6. A process of cooling in a continuous cycle which comprises the steps of:

exerting sufficient pressure on a superheated refrigerant to cause it to liquefy when cooled;
lowering the temperature of the pressurized refrigerant sufficiently to liquefy the same;
restricting and thereupon decreasing the pressure of all of the liquefied refrigerant;
dividing said liquefied refrigerant after the pressure thereof has been decreased;
directing a portion of said divided refrigerant into heat exchange relationship with moisture-laden air to be cooled;
collecting the moisture removed from the air as a consequence of extraction of heat from the latter by said portion;
controlling the flow of said portion to limit the extent of temperature reduction in said air;
directing all of the liquefied refrigerant while the flow thereof is restricted into heat exchange relationship

with the collection of moisture, and directing a second portion of said divided refrigerant into heat exchange relationship with all of the liquefied refrigerant while the flow thereof is restricted to sub-cool all of the latter before the pressure thereof is decreased; and

readmixing said portions after the same have extracted heat from said air and from said restricted flow of liquefied refrigerant respectively, whereby to present a superheated admixture prior to again pressurizing the same in continuation of the cycle.

7. A process of cooling in a continuous cycle which comprises the steps of:

- exerting sufficient pressure on a superheated refrigerant to cause it to liquefy when cooled;
- lowering the temperature of the pressurized refrigerant sufficiently to liquefy the same;
- restricting and thereupon decreasing the pressure of all of the liquefied refrigerant;
- dividing said liquefied refrigerant after the pressure thereof has been decreased;
- directing a portion of said divided refrigerant into heat exchange relationship with moisture-laden air to be cooled;
- collecting the moisture removed from the air as a consequence of extraction of heat from the latter by said portion;
- controlling the flow of said portion to limit the extent of temperature reduction in said air;
- directing all of the liquefied refrigerant while the flow thereof is restricted into heat exchange relationship with the collection of moisture, and directing a second portion of said divided refrigerant into heat exchange relationship with all of the liquefied refrigerant while the flow thereof is restricted to sub-cool all of the latter before the pressure thereof is decreased;
- readmixing said portions after the same have extracted heat from said air and from said restricted flow of liquefied refrigerant respectively, whereby to present a superheated admixture prior to again pressurizing the same in continuation of the cycle; and
- rendering the restriction of flow of said liquefied refrigerant responsive to the temperature of said admixture.

8. In combination:

- a first refrigerant-receiving evaporator having an inlet end and an outlet end, said first evaporator having an orifice at the outlet end thereof for restricting the flow of refrigerant outwardly thereof;
- a compressor for drawing refrigerant from the first evaporator when the latter is in fluid communication therewith and for exerting sufficient pressure on the refrigerant to cause it to liquefy when cooled;
- a first conduit placing the outlet end of said first evaporation in fluid communication with said compressor;
- a condenser coupled with said compressor for receiving refrigerant therefrom and for lowering the temperature of the refrigerant to liquefy the same;
- a second conduit placing said condenser in fluid communication with said first evaporator;
- a control across said second conduit for checking the flow of refrigerant from said condenser to said first evaporator to enable the compressor to maintain enough pressure on the refrigerant to keep the same liquid; and
- a second refrigerant-receiving evaporator having an inlet extremity in fluid communication with said second conduit between said control and said first evaporator and an outlet extremity in fluid communication with said first conduit between said outlet end of the first evaporator and said compressor, whereby one portion of the refrigerant flowing from the control flows through the first evaporator and the remaining portion of the refrigerant flows through said second evaporator in bypassing relationship to said first evap-

orator, said second evaporator being in heat exchange relationship to the refrigerant flowing from said condenser to said control.

9. The combination as set forth in claim 8, wherein is provided a valve at said outlet end of said first evaporator, said valve defining said orifice, said valve being operable to vary the cross-sectional area of said orifice.

10. A process of cooling in a continuous cycle which comprises the steps of:

- exerting sufficient pressure on a superheated refrigerant to cause it to liquefy when cooled;
- lowering the temperature of the pressurized refrigerant sufficiently to liquefy the same;
- restricting and thereupon decreasing the pressure of all of the liquefied refrigerant;
- dividing said liquefied refrigerant after the pressure thereof has been decreased whereby one portion of the refrigerant flows along one path and the remaining portion of the refrigerant flows along a second path;
- directing said one portion of the refrigerant into heat exchange relationship with a substance to be cooled;
- directing said remaining portion of said refrigerant into heat exchange relationship with all of the liquefied refrigerant while the flow thereof is restricted to thereby sub-cool all of the same before the pressure thereof is decreased;
- restricting the flow of said one portion after it has been directed into heat exchange relationship with said substance while maintaining said one path in fluid communication with said second path at the junction of said paths; and
- re-admixing said portions after said one portion has been restricted and after said remaining portion has been directed into heat exchange relationship with said liquefied refrigerant, whereby to present a superheated admixture prior to again pressurizing the same in continuation of the cycle.

11. The invention of claim 8, the outlet extremity of said second evaporator communicating with the first conduit between the compressor and the orifice.

12. In combination:

- a first refrigerant-receiving evaporator having an inlet end and an outlet end;
- a compressor for drawing refrigerant from the first evaporator when the latter is in fluid communication therewith and for exerting sufficient pressure on the refrigerant to cause it to liquefy when cooled;
- a first conduit placing the outlet end of said first evaporator in fluid communication with said compressor;
- a condenser coupled with said compressor for receiving refrigerant therefrom and for lowering the temperature of the refrigerant to liquefy the same;
- a second conduit placing said condenser in fluid communication with said first evaporator;
- a control across said second conduit for checking the flow of refrigerant from said condenser to said first evaporator to enable the compressor to maintain enough pressure on the refrigerant to keep the same liquid;
- a second refrigerant-receiving evaporator having an inlet extremity in fluid communication with said second conduit between said control and said first evaporator and an outlet extremity in fluid communication with said first conduit between said outlet end of the first evaporator and said compressor, whereby one portion of the refrigerant flowing from the control flows through the first evaporator and the remaining portion of the refrigerant flows through said second evaporator in bypassing relationship to said first evaporator, said second evaporator being in heat exchange relationship to the refrigerant flowing from said condenser to said control; and

means between said inlet end of the first evaporator and

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the compressor for producing a pressure drop in the refrigerant flowing to the compressor.

13. In combination:

- a first refrigerant-receiving evaporator having an inlet end and an outlet end;
 - a compressor for drawing refrigerant from the first evaporator when the latter is in fluid communication therewith and for exerting sufficient pressure on the refrigerant to cause it to liquefy when cooled;
 - a first conduit placing the outlet end of said first evaporator in fluid communication with said compressor;
 - a condenser coupled with said compressor for receiving refrigerant therefrom and for lowering the temperature of the refrigerant to liquefy the same;
 - a second conduit placing said condenser in fluid communication with said first evaporator;
 - a control across said second conduit for checking the flow of refrigerant from said condenser to said first evaporator to enable the compressor to maintain enough pressure on the refrigerant to keep the same liquid;
 - a second refrigerant-receiving evaporator having an inlet extremity adapted to receive a coolant and an outlet extremity adapted to discharge said coolant, said second evaporator being in heat exchange relationship to the refrigerant flowing from said condenser to said control; and
- means between said inlet end of the first evaporator and the compressor for producing a pressure drop in the refrigerant flowing to the compressor.

14. In combination:

- an evaporator having an inlet tube, an outlet conduit, and a chamber between the tube and the conduit for vaporizing a heat extracting medium as a consequence of heat being absorbed thereby from a substance to be cooled;
- a condenser for lowering the temperature of the medium to liquefy the same, said condenser having an outlet pipe connected with said tube;
- a by-pass between said tube and said conduit for feeding a portion of the medium around the evaporator to the conduit;
- a compressor connected with the conduit for drawing said medium from the chamber and the by-pass, feeding the medium to the condenser, and exerting sufficient pressure on the medium to cause it to liquefy when cooled in the condenser, there being a line between the compressor and the condenser;

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a control for checking the flow of said medium in the pipe to enable the compressor to maintain enough pressure thereon to keep it liquid; and

means placing at least a part of said pipe in thermal relationship to at least a part of said by-pass whereby to superheat and vaporize said portion of the medium, said parts of the pipe and the by-pass being disposed out of heat exchange relationship to the evaporator whereby the temperature of the superheated vapor flowing from the by-pass into the conduit is higher than that of the medium flowing from the evaporator into said conduit to thereby reduce the amount of liquid passing to the compressor.

- 15. A process of cooling in a continuous cycle which comprises the steps of;
 - exerting sufficient pressure on a superheated refrigerant to cause it to liquefy when cooled;
 - lowering the temperature of the pressurized refrigerant sufficiently to liquefy the same;
 - restricting and thereupon decreasing the pressure of all of the liquefied refrigerant;
 - directing a first portion of the decreased pressure refrigerant into heat exchange relationship with a substance to be cooled;
 - directing a second portion of the decreased pressure refrigerant into heat exchange relationship with all of the liquefied refrigerant while the flow thereof is restricted and before the pressure thereof is decreased and prior to again pressurizing said second portion in continuation of the cycle; and
 - producing a second pressure drop in said first portion of said refrigerant after said restriction thereof and prior to again pressurizing the same in continuation of the cycle, with second pressure drop being produced after the refrigerant enters into heated exchange relationship with said substance to be cooled.

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