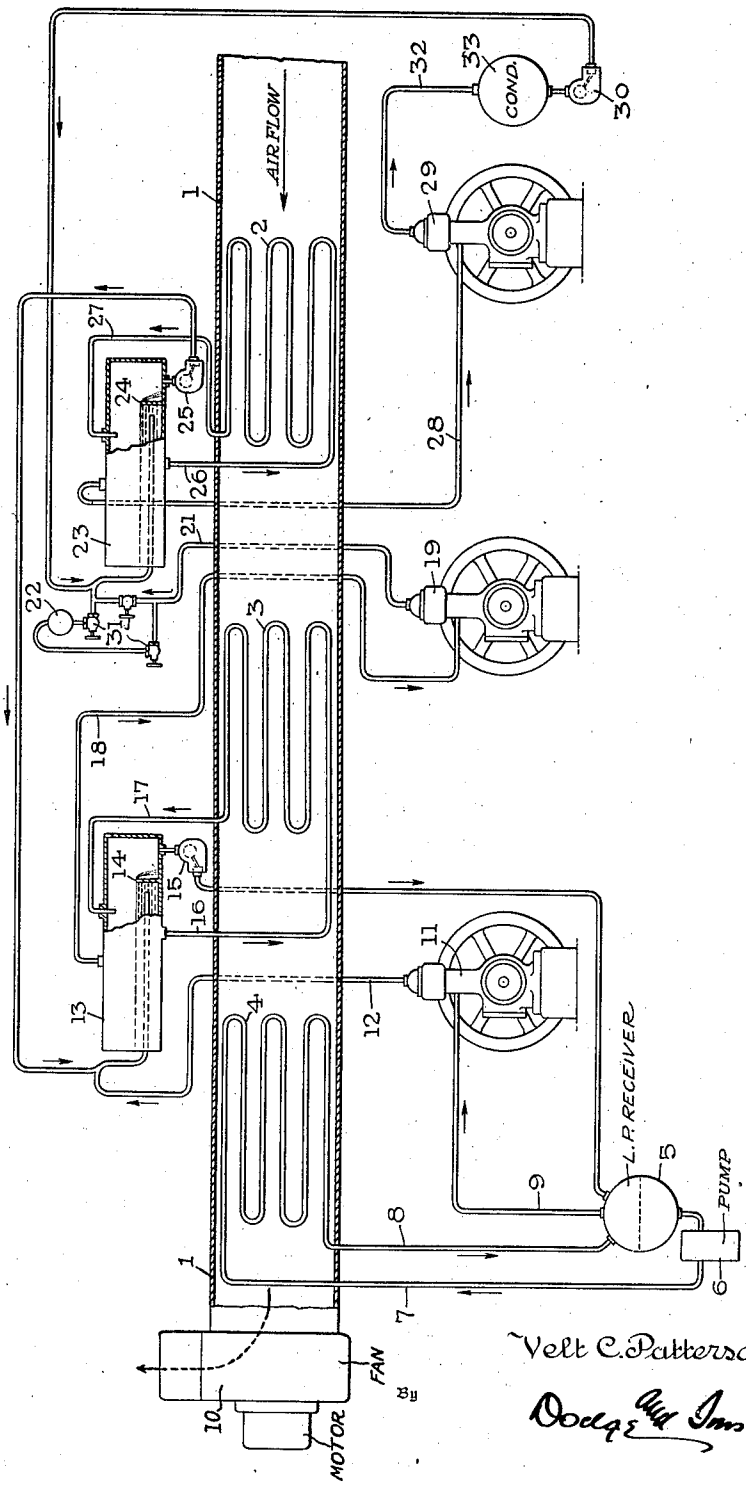
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REFRIGERATION

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REFRIGERATION

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9 Claims. (Cl. 62—115)

This invention relates to refrigeration and particularly to an economical system for cooling a stream of fluid by stage heat exchange.

The invention is intended for and well adapted to cooling a stream of air to very low temperatures. In the refrigeration circuit aspect it has the advantage of stage operation, using receiver suction traps between stages. In the air circuit aspect it has the advantages of stage cooling, such as better heat transfer and water elimination in the first stage or early stages so that frost formation on the low temperature surface is minimized.

The invention can be applied with two or more stages of compression (three will be used for an illustrative example) and involves stage cooling by a series of evaporators, all but the last of which are fed by interstage receiver suction traps, and hence operate at temperatures corresponding to the interstage pressures.

In the drawing, which is diagrammatic and not to scale, the single figure is an elevation with parts broken away to show internal details. In this diagram simple zig-zag evaporator coils are shown as extending in the direction of the length of the duct. Obviously any suitable type of evaporator may be used and would extend across the duct so as to exchange heat with the entire cross section of the air stream. The compressors are of appropriate size and type to give the necessary volumetric capacity and operate at appropriate compression ratios. They are not differentiated in the diagram since these details are matters of engineering, and will vary with the particular installation.

The duct 1 directs the air to be cooled in a path from right to left into heat exchanging relation with successive evaporators 2, 3 and 4 maintained at progressively lower temperatures. It is commonly desirable that the evaporator 2 operate above 32° F. so as to condense as much moisture as possible from the air without frost formation. Any suitable means, not shown, would then be used to collect and drain away the drip water. A fan 10 of any suitable type is used to circulate the air through the duct in the direction specified.

The low temperature evaporator 4 is fed with liquid refrigerant from a receiver 5 by circulating pump 6 and liquid line 7. Evaporated and unevaporated refrigerant return to the receiver 5 through line 8.

The vapor space in receiver 5 is connected by low pressure suction line 9 with the intake of low stage compressor 11. This discharges through line 12 into an interstage receiver suction trap whose shell is indicated at 13. In the shell is a weir or damp 14 which retains a bath of liquid refrigerant, to the level of the top of the weir in the left hand end of the shell (as viewed in the diagram). Connection 12 discharges into the liquid bath so retained.

Liquid overflowing weir 14 is delivered by a high-side float valve 15 to receiver 5. The evaporator 3 has a liquid supply connection 16 from the lower portion of the liquid bath in shell 13, and a vapor return connection 17 which leads to the vapor space in shell 13. From this space the intermediate suction line 18 leads to the intermediate stage compressor 19.

The discharge line 21 of compressor 19 leads either directly, or through a water-cooled gas cooler 22 to the shell 23 of a second interstage receiver suction trap identical with the one already described. This has a weir 24 on the discharge side of which is located a high-side float valve 25 which delivers any overflowing liquid refrigerant beneath the liquid bath in shell 13. As shown the float valve may deliver through the same horizontal dip pipe to which line 12 leads.

The evaporator 2 is connected by liquid line 26 and vapor line 27 in a manner similar to that described for evaporator 3. The suction line 28 leads to the high stage compressor 29.

The water-cooled gas cooler 22 may be interposed in the circuit or by-passed by proper manipulation of the three valves 31, as is obvious.

Compressor 29 discharges by line 32 into condenser 33, from which a third high-side float valve 30 delivers liquid refrigerant to the liquid bath in shell 23, preferably, and as shown through the dip pipe to which line 21 delivers.

The operation of the system will be readily understood from the description given. The use of intermediate receiver suction traps is known, but the present invention relates a series of evaporators to these traps and thus secures the advantages of stage cooling without any extra complication.

Because the weirs and the high-side floats impose a positive control, no troublesome regulating apparatus is needed. The evaporator temperatures are controlled by the inherent control of interstage pressures, and without the use of thermostats, superheat control expansion valves or other sensitive equipment. This is peculiarly important where low temperatures are to be dealt with.

As suggested the system can be modified to meet the exigencies of particular cases. Specifically, two or more stages can be used, the desir-

ability of additional stages increasing as the final temperature of the cooled stream is lowered.

What is claimed is:

1. A refrigerative circuit containing volatile liquid refrigerant and comprising in combination, a low pressure receiver; a receiver suction trap; a low stage compressor arranged to withdraw vaporous refrigerant from said receiver and deliver it at higher pressure into contact with liquid in said trap; liquefying means including a higher stage compressor arranged to withdraw vaporous refrigerant from said trap, liquefy it and return it to said trap; two evaporators; means serving to supply liquid refrigerant from said receiver to one evaporator and cause it to evaporate therein under receiver pressure; means serving to supply liquid refrigerant from said trap to the other evaporator and cause it to evaporate therein under trap pressure; and means serving to deliver excess liquid refrigerant from said trap to said receiver.

2. A refrigerative circuit containing volatile liquid refrigerant and comprising in combination, a low pressure receiver; a receiver suction trap having means for retaining a bath of liquid and permitting overflow therefrom; a low stage compressor arranged to withdraw vaporous refrigerant from said receiver and deliver it at higher pressure into contact with the liquid bath in said trap; liquefying means including a higher stage compressor arranged to withdraw vaporous refrigerant from said trap, liquefy it and return it in the liquid phase to the liquid bath in said trap; two evaporators; means serving to supply liquid refrigerant from said receiver to one evaporator and cause it to evaporate therein at receiver pressure; means serving to supply liquid refrigerant from the bath in said trap to the other evaporator and cause it to evaporate therein at trap pressure; and a high side float valve serving to deliver liquid refrigerant passing said overflow from said trap to said receiver.

3. A refrigerative circuit containing volatile liquid refrigerant and comprising in combination, a low pressure receiver; a receiver suction trap having means for retaining a bath of liquid and permitting overflow therefrom; a low stage compressor arranged to withdraw vaporous refrigerant from said receiver and deliver it at higher pressure into contact with the liquid bath in said trap; liquefying means including a higher stage compressor arranged to withdraw vaporous refrigerant from said trap, liquefy it and return it in the liquid phase to the liquid bath in said trap; two evaporators; means serving to supply liquid refrigerant from said receiver to one evaporator and cause it to evaporate therein at receiver pressure; means serving to supply liquid refrigerant from the bath in said trap to the other evaporator and cause it to evaporate therein at trap pressure; a high side float valve serving to deliver liquid refrigerant passing said overflow from said trap to said receiver; and means for circulating fluid to be cooled into heat exchanging relation first with the second named and then with the first named evaporator.

4. In a refrigerating circuit, containing volatile refrigerant, the combination of compressing means having at least three stages of compression; intermediate receiver suction traps between compression stages; a low pressure receiver from which the first stage draws vaporous refrigerant; condensing means to which the last stage of compression delivers compressed refrigerant; evaporators respectively fed with liquid refrigerant by the receiver and the various suction traps, and so connected that evaporation of refrigerant occurs at the pressure of the connected receiver or trap; liquid line connections whereby the condenser delivers liquid refrigerant to the last suction trap and the traps each deliver excess liquid refrigerant to the preceding trap and the first trap delivers to the receiver; means interposed in said liquid connections to preserve the pressure differentiations of the various stages of compression; and means for passing a fluid to be cooled, successively into heat exchanging relation with said evaporators first with the high pressure and last with the low pressure evaporator.

5. In a refrigerating circuit, containing volatile refrigerant, the combination of compressing means having at least three stages of compression; intermediate receiver suction traps between compression stages; a low pressure receiver from which the first stage draws vaporous refrigerant; condensing means to which the last stage of compression delivers compressed refrigerant; evaporators respectively fed with liquid refrigerant by the receiver and the various suction traps, and so connected that evaporation of refrigerant occurs at the pressure of the connected receiver or trap; liquid line connections whereby the condenser delivers liquid refrigerant to the last suction trap and the traps each deliver excess liquid refrigerant to the preceding trap and the first trap delivers to the receiver; and means interposed in said liquid connections to preserve the pressure differentiations of the various stages of compression.

6. A refrigerative circuit, containing a volatile refrigerant and comprising a low pressure receiver, a condenser, and stage compressing means including interstage receiver suction traps interposed between successive stages of compression, the path from the low pressure receiver to the condenser being from the low pressure receiver to the low stage of compression, thence through successive traps and successive stages of compression in alternation, and from the final stage of compression to the condenser, the path from the condenser to the low pressure receiver being from the condenser to the last interstage trap, thence by liquid line from trap to trap in the order of descending pressures and from the lowest pressure trap to the low pressure receiver; means interposed in said liquid line serving to pass liquid while maintaining the stage pressure differentials; and evaporators respectively fed by and operated at the pressures of the low pressure receiver and respective receiver suction traps.

7. A refrigerative circuit, containing a volatile refrigerant and comprising a low pressure receiver, a condenser, and stage compressing means including interstage receiver suction traps interposed between successive stages of compression, the path from the low pressure receiver to the condenser being from the low pressure receiver to the low stage of compression, thence through successive traps and successive stages of compression in alternation, and from the final stage of compression to the condenser, the path from the condenser to the low pressure receiver being from the condenser to the last interstage trap, thence by liquid line from trap to trap in the order of descending trap pressures and from the lowest pressure trap to the receiver; means interposed in said liquid line serving to pass liquid while maintaining the stage pressure differentials, said means comprising high side float valves respec-

tively controlling the discharge from the condenser and from successive traps; overflow means in each trap arranged to maintain a liquid bath therein and to deliver the overflow therefrom to the related high side float valve; and evaporators respectively fed by and operated at the pressures of the low pressure receiver and respective receiver suction traps.

8. A refrigerative circuit, containing a volatile refrigerant and comprising a low pressure receiver, a condenser, and stage compressing means including interstage receiver suction traps interposed between successive stages of compression, the path from the low pressure receiver to the condenser being from the low pressure receiver to the low stage of compression, thence through successive traps and successive stages of compression in alternation, and from the final stage of compression to the condenser, the path from the condenser to the low pressure receiver being from the condenser to the last interstage trap, thence by liquid line from trap to trap in the order of descending pressures and from the lowest pressure trap to the low pressure receiver; means interposed in said liquid line serving to pass liquid while maintaining the stage pressure differentials; and an evaporator fed by and operated at the pressure of the low pressure receiver.

9. A refrigerative circuit containing volatile liquid refrigerant and comprising in combination, a low pressure receiver; a receiver suction trap having means for retaining a bath of liquid and permitting overflow therefrom; a low stage compressor arranged to withdraw vaporous refrigerant from said receiver and deliver it at higher pressure into contact with the liquid bath in said trap; liquefying means including a higher stage compressor arranged to withdraw vaporous refrigerant from said trap, liquefy it and return it in the liquid phase to the liquid bath in said trap; a high side float valve serving to deliver to said low pressure receiver liquid overflow from said trap; an evaporator and means serving to supply liquid refrigerant from said low pressure receiver to said evaporator and cause it to evaporate therein at receiver pressure.

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