

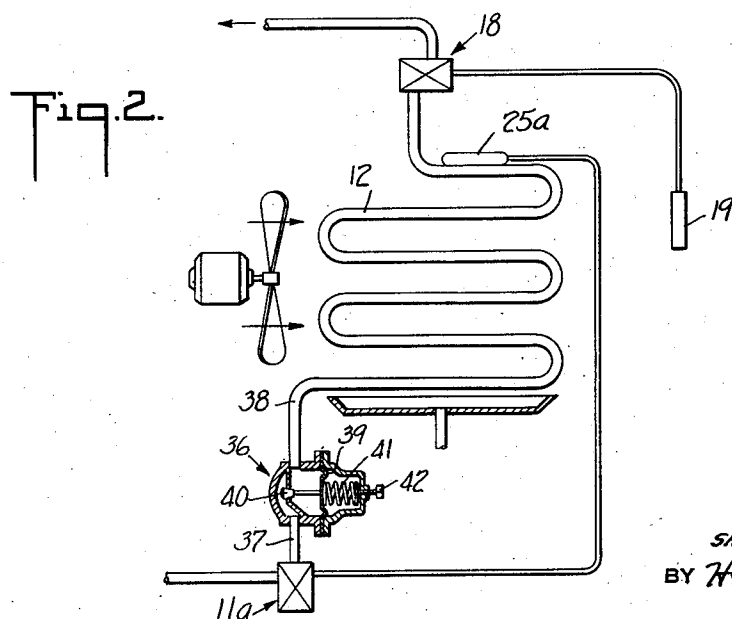
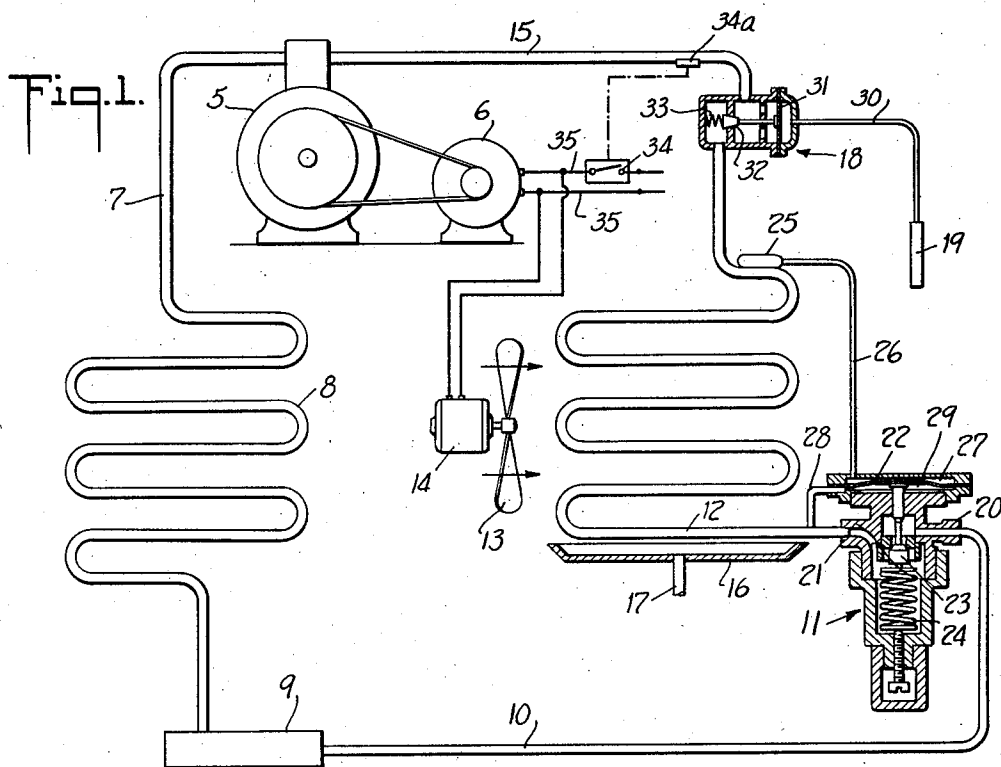
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REFRIGERATION CONTROL

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REFRIGERATION CONTROL

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This invention relates to the control of refrigerating systems, and more particularly to the control of refrigerant evaporation in refrigerating systems of the compression type.

The general object of the invention is to provide an improved method of and means for controlling the production of refrigerating effect by the evaporator of a refrigerating system of the compression type.

It is another object of the invention to provide an improved method of and means for controlling the evaporation of refrigerant in a refrigerating system of the compression type in a manner which is particularly applicable to air conditioning systems for comfort and commercial purposes.

It is another object of the invention to provide an improved system for controlling the operation of a refrigerant evaporator which is simple and effective, flexible, inexpensive, and entirely reliable in operation.

It is another object of the invention to provide an improved method of and means for controlling the operation of a refrigerating system including an evaporator whereby the temperature of the evaporator is varied in accordance with load requirements, but is prevented from rising above a predetermined point at any time during operation of the refrigerating system. Thus when an evaporator controlled in accordance with the invention is employed in an air conditioning system, the temperature of the evaporator may be increased as the temperature, for example, of the air in a conditioned area served thereby decreases, and may be decreased as the temperature of the air increases, but the temperature of the evaporator will not be permitted to rise above a predetermined point, selected so that it is normally below the dewpoint of the air to be conditioned. Thus dehumidification of the conditioned air will continue as long as the evaporator remains in operation.

A feature of the invention resides in controlling the rate at which refrigerant is withdrawn from an evaporator to control the temperature of the evaporator, and so controlling the admission of refrigerant to the evaporator that the pressure therein and temperature thereof are prevented from rising above predetermined points.

Another feature of the invention resides in controlling the rate at which refrigerant is withdrawn from an evaporator to control the temperature of the evaporator, and so controlling the admission of refrigerant to the evaporator that

the pressure therein and temperature thereof are prevented from rising above predetermined points, and modulating the supply of refrigerant to the evaporator to maintain a predetermined degree of superheat in refrigerant withdrawn from the evaporator when the temperature of the withdrawn refrigerant is below a predetermined point.

Another feature of the invention resides in regulating the action of a refrigerant evaporator by contemporaneously and independently variably controlling the rate at which refrigerant is supplied to the evaporator and the rate at which the refrigerant is withdrawn therefrom.

Another feature of the invention resides in controlling the admission of refrigerant to and the withdrawal thereof from the evaporator of a refrigerating system, in such manner that a predetermined degree of superheat is maintained in the refrigerant leaving the evaporator whenever the evaporator temperature is below a predetermined point, and in such manner that the temperature of the evaporator is prevented from rising above said predetermined point, regardless of changes in the heat load on the evaporator. Thus, maximum effectiveness of operation is maintained throughout the major portion of the operating range, and the evaporator temperature is at all times maintained at a sufficiently low temperature to accomplish dehumidification regardless of decreases in the sensible cooling load on the evaporator.

Other objects, features and advantages of the invention will be more apparent from the following description, to be read in connection with the accompanying drawing, in which:

Fig. 1 illustrates diagrammatically a refrigerating system of the compression type embodying the invention; and

Fig. 2 is a fragmentary view diagrammatically illustrating a modified form of the invention.

Referring to the drawing, the numeral 5 designates a compressor of any desired type illustrated as being driven by an electric motor 6. Compressed refrigerant from the compressor is delivered through line 7 to a condenser 8 of any desired type in which it is liquified, the liquid refrigerant then passing to a liquid receiver 9. Liquid refrigerant from receiver 9 is delivered through liquid line 10 to an expansion valve 11 through which it is admitted to evaporator 12 of any desired type or construction. As illustrated, the evaporator 12 is positioned in the path of a stream of air circulated thereover by fan

13 driven by motor 14. Absorption of heat from the air stream vaporizes refrigerant within coil 12 and the vaporized refrigerant is withdrawn through suction line 15 by the compressor 5, thus completing the refrigerating cycle.

A suitable drip pan or the like 16 may be provided for collecting moisture precipitated from the air contacting with the evaporator 12 and this condensate may be disposed of in any desired manner. As illustrated, a drain connection 17 is provided for draining condensate from the pan 16. If desired, this condensate may be delivered over the surfaces of the condenser 8 for facilitating the condensation of refrigerant therein or may be utilized or disposed of in any other desired manner.

Interposed in the suction line 15 is a back pressure regulating valve 18 under the control of a thermal bulb or the like 19, suitably located at any desired point. As illustrated the thermal bulb is located in the path of air discharged from the apparatus after contact with the evaporator 12, but it is to be understood that this control element may be located at any desired point in the air conditioning system served by the refrigerating apparatus and thus, for example, may be located either in an enclosure served thereby or in the path of air delivered to the evaporator for conditioning thereby.

The valve 11 is a thermal expansion valve of the gas charged type. The valve includes an inlet 20 and an outlet 21 which connects with the evaporator 12. The expansion valve 11 is also provided with a diaphragm 22, a plunger actuated valve 23 and an adjustable spring 24 which opposes the action of the diaphragm 22. A bulb 25 filled with a suitable gas is connected by a conduit 26 to a chamber 27 on the upper side of the diaphragm 22. Another conduit 28 connects with a chamber 29 on the lower side of the diaphragm 22 and also connects with the interior of the evaporator 12. The thermal expansion valve 11 is therefore responsive to both the pressure of the evaporator 12 and the pressure of the gas in the bulb 25 and conduit 26.

The structural features of the expansion valve 11 as thus described, are well known in the art but it is to be understood that the valve herein employed differentiates from conventional thermal expansion valves in that the valve 11 is of the gas charged type, the action of which may be described as follows:

The valve is charged by the introduction of refrigerant vapor only into the bulb 25 and conduit 26 at a predetermined surrounding temperature. The result is that in operation up to a certain suction temperature there is liquid in the bulb 25 which is attached to the suction line in conventional manner so as to be in heat exchange relation therewith. As long as this condition prevails, the valve 11 tends to hold a constant superheat of the gas in the suction line, and as a consequence tends to keep the evaporator fully active. Above this temperature, which is approximately the charging temperature, all of the fluid in the bulb is in the form of vapor and the valve acts substantially as a constant pressure expansion valve, limiting the amount of refrigerant fed to the evaporator so as to maintain substantially a fixed upper pressure. At a slightly higher pressure the valve closes and will not open until the pressure in the evaporator is again lowered.

The operation of the evaporator is further controlled by the back pressure regulating valve 18

which may be of any desired construction, but which is so arranged that as the heat load upon the evaporator is increased, the opening of the valve is increased to permit a lowering of the pressure within the evaporator, thus to effect a corresponding reduction in temperature of the evaporator which is required to compensate for the increase in the heat load thereon. Conversely, when the heat load on the evaporator is decreased, the valve is correspondingly closed to provide for a higher suction pressure and hence evaporator temperature. The suction valve 18 may take the form illustrated in the drawing. Thus, as the temperature affecting the thermal bulb 19 is increased, there is an increase in the pressure transmitted to the valve through line 30 and this increased pressure affecting the diaphragm 31 causes the closure member 32 to be removed from its seat, thus opening the valve more widely against the balancing action of spring 33. As the temperature affecting the thermal bulb 19 is lowered, the pressure transmitted through line 30 will fall and the closure member will be moved under the influence of spring 33 to effect reduced opening of the valve 18, so that the evaporator pressure and temperature will be increased appropriately responsive to the decrease in heat load on the evaporator. The same operation obtains whether the bulb 19 is located in the air discharge or in the conditioned area or return duct.

Whenever the system is to be rendered operative, the switch 34, in one of the electrical leads 35 energizing the compressor motor 6 and the fan motor 14, is closed. This closure of the switch 34 may be accomplished manually or it may be accomplished automatically under the control of a suitable control element, as for example low pressure cut out 34a in the suction line 15, opening the switch whenever the pressure in the suction line is below a predetermined point.

In operation, assuming the switch 34 to be closed in response to a demand for operation of the refrigerating system, the temperature of the evaporator 12 will be controlled by the modulating back pressure regulating valve 18, the degree of opening of which is varied in accordance with changes in the load on the evaporator.

The thermal expansion valve 11 will meter the refrigerant supply to the evaporator to provide desired control of the degree of superheat in the refrigerant leaving the evaporator. As the suction temperature tends to rise above a predetermined point corresponding to the charging temperature of the bulb 25, the complete vaporization of the gas charge in the bulb 25 will cause the supply of refrigerant to the evaporator to be throttled. Thus, the suction temperature will at all times be maintained at or below a predetermined point. Thus, although the action of the suction valve 18 might tend to cause a relatively high suction pressure and temperature to prevail within the evaporator, the action of the gas charged thermal expansion valve 11 is such that the suction pressure and temperature are nevertheless prevented from rising above a predetermined point.

When the sensible cooling load on the evaporator 12 is relatively low, there will be a tendency for the thermal bulb 19, operating on suction valve 18, to cause a relatively high temperature to be maintained in the evaporator, and this temperature in many cases would be higher than the dewpoint of the air contacting the evaporator 12 so that there would be no de-

humidification. However, the provision of gas charged expansion valve 11 predetermines the maximum operating temperature of the evaporator; and if this maximum temperature is appropriately chosen so that it is lower than the dewpoint of the air contacting the evaporator at all times, dehumidification will be effected at all times during operation of the evaporator.

Thus, it will be seen that the present invention provides for accurate control of the dry bulb temperature of a conditioned enclosure whenever there is at least a predetermined heat load on the refrigerating system, and gives assurance that dehumidification will continue to occur even though there should be an abnormally low sensible heat load. In this respect the invention overcomes a shortcoming of many refrigerating system controls heretofore employed.

It will be appreciated that if a refrigerating system in accordance with the invention is designed for a particular installation having a known or predetermined load, the design may be such as to provide for accurate temperature control substantially at all times. In the event of abnormally low sensible heat loads, however, the invention gives assurance that dehumidification will continue to be effected so long as the evaporator remains in operation.

Further it will be noted that the evaporator at all times operates at the highest temperature consistent with meeting load requirements. Hence if the system is used for commercial refrigeration, as in the storage of food products or the like, excessive dehumidification will be avoided.

Fig. 2 illustrates a modified form of the invention in which the method of operation described above is followed although a slightly different arrangement of elements is employed for this purpose. In Fig. 2 the expansion valve 11a is of the conventional type as distinguished from the gas charged thermal expansion valve 11 of Fig. 1. The suction valve 18 and the control element 19 are as described above. Whenever the temperature of the evaporator is above a predetermined point under the control of suction valve 18, the expansion valve 11a operates to maintain a predetermined degree of superheat in the refrigerant leaving the evaporator 12. In this embodiment of the invention, however, there is interposed an additional valve 36 between the expansion valve 11a and the evaporator 12. The valve 36 comprises an inlet connection 37 and an outlet connection 38 which communicates with the evaporator 12. The pressure in the evaporator affects the diaphragm 39 which controls the closure member 40. As the pressure in the evaporator rises above a predetermined point, determined by the setting of adjustment screw 42, the diaphragm is moved against the force of the balancing spring 41 and thus causes the closure member 40 of the valve to restrict the supply of refrigerant to the evaporator. The restriction of the supply of refrigerant to the evaporator will result in the maintenance of a lower pressure within the evaporator due to the suction action of the compressor 6. Thus, the evaporator temperature will be prevented from rising above a predetermined point regardless of the adjustment of the suction valve 18.

Since many changes may be made in the invention without departing from the scope thereof, it is intended that all matter set forth in the above description, or shown in the accompanying

drawing, be regarded as illustrative only and not in a limiting sense.

I claim:

1. The method of regulating the action of the evaporator of a compression type refrigerating system which comprises supplying refrigerant to the evaporator for evaporation therein, withdrawing evaporated refrigerant from the evaporator, regulating the withdrawal of refrigerant from the evaporator in such manner that the temperature therein is caused to rise to a predetermined point, regulating the admission of refrigerant to the evaporator after the temperature therein has risen to said predetermined maximum point in such manner that the effective area of the evaporator will be varied, the effective area being maintained at said predetermined maximum temperature.

2. The method of regulating the action of the evaporator of a compression type refrigerating system which comprises supplying refrigerant to the evaporator for evaporation therein, withdrawing evaporated refrigerant from the evaporator, variably controlling the withdrawal of refrigerant from the evaporator in response to variations in load in such manner that upon a drop in load the temperature within the evaporator will rise, regulating the admission of refrigerant to the evaporator so that substantially a flooded condition is maintained in the evaporator until the temperature therein rises to a predetermined point whereupon a partially flooded condition will be maintained therein with the temperature of the effective portion of the evaporator not exceeding said predetermined point.

3. The method of regulating the action of the evaporator of a compression type refrigeration system which comprises supplying refrigerant to said evaporator for evaporation therein, withdrawing evaporated refrigerant from said evaporator, increasing the back pressure to a drop in load to establish a desired maximum temperature within an effective portion of the evaporator, and causing the admission of refrigerant to the evaporator to be throttled when said temperature in the evaporator is reached.

4. The method of regulating the action of the evaporator of a compression type refrigeration system which comprises supplying refrigerant to said evaporator for evaporation therein, withdrawing evaporated refrigerant from said evaporator, variably regulating the withdrawal of refrigerant from the evaporator to produce a desired back pressure therein, and varying the admission of refrigerant to the evaporator responsive to variations in load affecting the system, said last step being accomplished by a gas charged expansion valve operating to vary the active surface of the evaporator, the active surface being at a prescribed maximum temperature corresponding to the pressure maintained in the evaporator.

5. The method of regulating the action of the evaporator of a compression type refrigeration system which comprises supplying refrigerant to said evaporator for evaporation therein, withdrawing evaporated refrigerant from said evaporator, variably throttling the flow of evaporated refrigerant withdrawn from said evaporator in accordance with changes in temperature of a medium affected by said evaporator, and varying the active surface of the evaporator by throttling the supply of refrigerant admitted thereto responsive to variations in load so that substantially the same pressure will be maintained in the

evaporator under a partial load condition, but different portions of the evaporator will be at different temperatures.

6. The method of regulating the action of the evaporator of a compression type refrigeration system which comprises supplying refrigerant to said evaporator for evaporation therein, withdrawing evaporated refrigerant from said evaporator, maintaining a predetermined degree of superheat in refrigerant leaving the evaporator whenever the evaporating pressure is below a predetermined point under full load conditions, and throttling the supply of refrigerant to said evaporator when the evaporating pressure is above said predetermined point to cause different portions of the evaporator to have a desired maximum temperature responsive to variations in partial load conditions.

7. The method of conditioning air which consists in passing the air in heat exchange relation with the evaporator of a compression type refrigerating system, variably restricting the flow of evaporated refrigerant withdrawn from said evaporator in response to changes in the dry bulb temperature of air cooled by said evaporator and throttling, responsive to variations in partial load conditions while the system is in operation, the supply of refrigerant to the evaporator to cause different portions of the evaporator to be active and at a prescribed maximum temperature.

8. The method of conditioning air which consists in passing the air in heat exchange relation with the evaporator of a compression type refrigerating system, variably restricting the flow of evaporated refrigerant withdrawn from said evaporator in response to changes in the dry bulb temperature of air cooled by said evaporator and throttling the supply of refrigerant to the evaporator whenever the temperature of the evaporator tends to rise above a predetermined maximum temperature corresponding to the pressure established in the evaporator responsive to restriction of flow of refrigerant therefrom in such manner that different portions of the evaporator will be caused to be active at said predetermined maximum temperature responsive to variations in partial load conditions.

9. An apparatus of the character described, including, in combination, a refrigerant evaporator, means for supplying refrigerant to said evaporator for evaporation therein, means for withdrawing evaporated refrigerant from said evaporator, means for passing a medium to be conditioned in heat exchange relation with said evaporator, means for regulating the admission of refrigerant to said evaporator, and means for regulating the withdrawal of refrigerant from said evaporator, said last-mentioned means including a control device responsive to a characteristic of said medium, said means for regulating the admission of refrigerant to said evaporator being responsive to variations in load conditions to cause different portions of the evaporator to be active at a predetermined maximum temperature.

10. An apparatus of the character described, including, in combination, a refrigerant evaporator, means for supplying refrigerant to said evaporator for evaporation therein, means for withdrawing evaporated refrigerant from said evaporator, means for passing a medium to be conditioned in heat exchange relation with said evaporator, a back pressure regulating valve for regulating the withdrawal of evaporated refrigerant from said evaporator to cause the pressure within the evaporator to rise to a predeter-

mined maximum, and means responsive to pressure within said evaporator for throttling the supply of refrigerant to said evaporator to cause a portion of the evaporator to be active at a temperature corresponding to said pressure, said active portion of the evaporator being continuous in extent, the extent of said active portion varying in accordance with variations in load conditions.

11. An apparatus of the character described, including, in combination, a refrigerant evaporator, means for supplying refrigerant to said evaporator for evaporation therein, means for withdrawing evaporated refrigerant from said evaporator, means for passing a medium to be conditioned in heat exchange relation with said evaporator, a back pressure regulating valve for regulating the withdrawal of evaporated refrigerant from said evaporator to cause the pressure within the evaporator to rise to a predetermined maximum, means for controlling the operation of said back pressure regulating valve in accordance with a characteristic of said medium, and means responsive to an operating condition of said evaporator to control the admission of refrigerant to said evaporator to cause a portion of the evaporator to be effective at a temperature corresponding to said maximum pressure, said portion varying in extent with variations in load.

12. An apparatus of the character described, including, in combination, a refrigerant evaporator, means for supplying refrigerant to said evaporator for evaporation therein, means for withdrawing evaporated refrigerant from said evaporator, means for passing a medium to be conditioned in heat exchange relation with said evaporator, a back pressure regulating valve for regulating the withdrawal of evaporated refrigerant from said evaporator, means for controlling the operation of said back pressure regulating valve in accordance with a characteristic of said medium, and means including a gas charged expansion valve for controlling the admission of refrigerant to said evaporator in such manner that upon a drop in load below a predetermined minimum the evaporator will be active only in part, the active part being at a temperature corresponding to the pressure in the evaporator.

13. In combination with a refrigerant compressor, refrigerant condenser and refrigerant evaporator, connected serially in refrigerant flow relationship; a thermal expansion valve of the gas charged type for controlling the admission of refrigerant to said evaporator, and a modulating valve regulating the withdrawal of evaporated refrigerant from said evaporator, said last-mentioned valve serving variably to regulate the pressure of said evaporator, the charge within said expansion valve becoming completely gaseous when the pressure within said evaporator rises above a predetermined point, said valve serving to reduce the active surface, upon a drop in load, while the pressure in the evaporator is above said predetermined point.

14. In a refrigerating system wherein a refrigerant is compressed, condensed and evaporated in a continuous cycle, the combination of an evaporator, a connection for conveying refrigerant vapor from the evaporator to the compressor, a valve in said connection, means for modulating the degree of opening of said valve in accordance with the load on said evaporator, and second valve means for controlling the admission of refrigerant to said evaporator, said second valve means being adapted and arranged to throttle the supply of refrigerant to the evap-

orator, said second valve means comprising an expansion valve operative responsive to differences in pressure between the pressure in the evaporator and the pressure of a refrigerant within a tube connected to said valve and in heat exchange relation with the discharge end of said evaporator.

15. In combination with a refrigerant compressor, refrigerant condenser and refrigerant evaporator, connected serially in refrigerant flow relationship; means responsive to changes in heat load on said evaporator for variably controlling

5 the pressure within said evaporator in accordance with variations in load demands on said evaporator, refrigerant-supply-throttling means responsive to a rise in pressure within said evaporator for throttling the supply of refrigerant to the evaporator to cause a portion of the evaporator to be active at a temperature corresponding to the pressure in the evaporator, and means for rendering said compressor inoperative when 10 the pressure in the suction line to the compressor falls below a predetermined minimum.

SAM F. SHAWHAN.

CERTIFICATE OF CORRECTION.

Patent No. 2,282,385.

May 12, 1942.

SAM F. SHAWHAN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 41, claim 3, after the word "pressure" insert --responsive--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of July, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.