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REFRIGERATING SYSTEM

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Fig. 1.

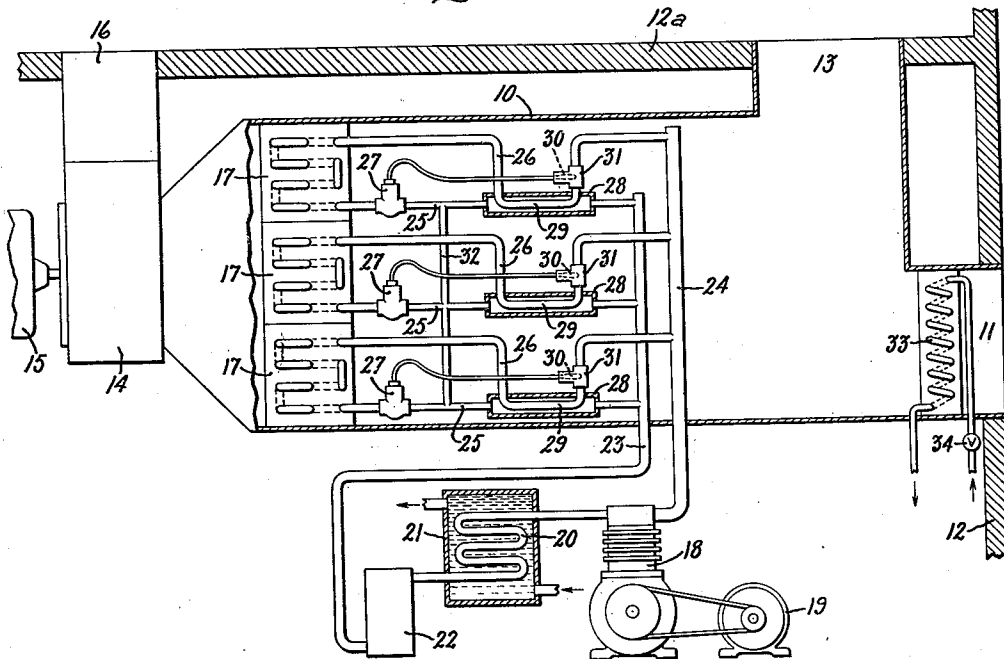
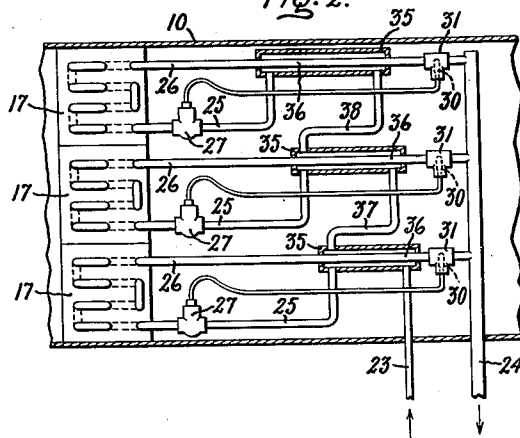


Fig. 2.



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UNITED STATES PATENT OFFICE

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REFRIGERATING SYSTEM

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5 Claims. (Cl. 62—8)

My invention relates to refrigerating systems of the type having a plurality of evaporators, and particularly to refrigerant flow control apparatus for such systems.

When a single evaporating coil, such as those employed in air conditioning systems, is operated from a compressor-condenser unit, it is common practice to control the flow of liquid refrigerant to the evaporator by means of a thermostatic expansion valve. The thermostatic expansion valve controls the flow of liquid refrigerant to the evaporator in accordance with the pressure within the evaporator and the temperature of the vaporized refrigerant withdrawn from the evaporator and tends to maintain a predetermined number of degrees of superheat in the vapor withdrawn from the evaporator at the point in the suction line where the temperature responsive element is located. In systems in which the evaporator operates at relatively low temperatures, there may not be sufficient heat in the withdrawn vaporized refrigerant to actuate properly the temperature responsive element of the valve; in such cases it is a frequent practice to employ a heat exchanger between the liquid and suction lines so that heat from the warm liquid is available to increase the temperature of the withdrawn vapor and superheat it sufficiently for proper actuation of the valve. However, when a plurality of such evaporators are connected to a single condensing unit, each evaporator being provided with a respective individual thermostatic expansion valve, the suction pressures in the several evaporators tend to become constant at an average value and the valves, therefore, operate essentially as temperature responsive valves. Should one of the valves close during the operation of the system, the flow of liquid refrigerant to the corresponding evaporator will be stopped and obviously the flow of warm liquid to the evaporator will stop so that no heat is available to increase the temperature of the vaporized refrigerant removed from the evaporator after the closing of the valve; since the pressure tends to be constant the valve may, therefore, remain closed for a prolonged period. This is particularly noticeable in systems in which the cooling unit is used to reduce the temperature of air which is already at a relatively low temperature. Accordingly, it is an object of my invention to provide a refrigerating system including a plurality of evaporators each controlled by a temperature responsive valve and having a heat exchanger between its liquid and suction lines, and including an improved ar-

angement for insuring proper operation of all the valves during the operation of the system.

Another object of my invention is to provide a refrigerating system including a plurality of evaporators each controlled by a respective temperature responsive valve, and including an improved arrangement for facilitating the even distribution of refrigerant load among the several evaporators.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing, in which Fig. 1 illustrates diagrammatically an air conditioning system partly in section employing a refrigerating system embodying my invention, and Fig. 2 illustrates the cooling coils of a system similar to that of Fig. 1 employing another embodiment of my invention.

Briefly, the system disclosed comprises a plurality of evaporator elements arranged in an air circulating duct and connected to a common compressor-condenser unit by liquid and suction lines. Each evaporator is provided with a thermostatic expansion valve for controlling the flow of liquid refrigerant and a heat exchanger for insuring sufficient superheat at the location of the temperature responsive element of the valve. In order to insure an adequate supply of heat for superheating of the refrigerant withdrawn from the evaporators, the liquid lines are arranged so that liquid refrigerant may flow through one or more of the heat exchangers whether or not the valves associated with those exchangers are open.

Referring now to the drawing, in Fig. 1 I have illustrated an air conditioning system including a duct or casing 10 having a fresh air inlet 11 passing through an outside wall 12 of the building in which the system is located and a return air inlet 13 passing through a wall 12a of the room to be conditioned. Fresh and recirculated air are drawn into the casing by operation of a fan 14 driven by a motor 15 and the air mixture is discharged into the enclosure through a duct 16 passing through the wall 12a. In order to cool the air in the casing 10, I provide a plurality of evaporators 17 connected in the refrigerant circuit of a refrigerating system including a compressor 18 driven by a motor 19, a condenser 20 arranged in a casing 21, and a liq-

uid receiver 22. Liquid refrigerant from the receiver 22 is supplied to the evaporators 17 through a liquid inlet connection or manifold 23 and vaporized refrigerant is withdrawn from all the evaporators 17 through a vapor outlet connection or suction manifold 24. Liquid refrigerant is supplied to the evaporators from the manifold 23 through liquid inlet conduits 25 and refrigerant vaporized in the evaporators is conducted therefrom to the manifold 24 through outlet or suction conduits 26. Each evaporator 17 is provided with a thermostatic expansion valve 27 in the conduit 25 and adjacent the evaporator for controlling the flow of liquid refrigerant to the evaporator. In order to insure sufficient heating of the vaporized refrigerant withdrawn from each evaporator to provide sufficient superheat for satisfactory operation of the expansion valve, I provide each evaporator with a heat exchanger. Each heat exchanger comprises a casing constituting an enlarged portion 28 of the inlet conduit 25 of the respective evaporator through which passes a portion 29 of the suction conduit of the same evaporator. The thermostatic valves 27 are controlled by thermal elements 30 mounted in T-connections 31 and which are responsive to the temperature of the vaporized refrigerant withdrawn from their respective evaporators adjacent the outlets of the heat exchangers. The elements 30 are immersed in the vaporized refrigerant in the suction conduits in order to afford greater sensitivity than is possible with the conventional element clamped to the outside of the suction conduit.

During certain conditions of operation, one of the valves 27 may close and there is, therefore, a tendency to stop the flow of refrigerant through the corresponding heat exchanger and thereby stop the supply of heat for providing adequate superheat of the vapor in the suction conduit 26 around the thermal element 30. In order to prevent the stopping of flow of the warm liquid refrigerant through the heat exchanger casing 28 of an evaporator when its valve 27 is closed, I provide an equalizing manifold 32 connecting the several liquid lines 25 at points between the valves 27 and the heat exchangers. Should any one of the valves 27 close, the enlarged portion 28 of the corresponding liquid line will remain in an open parallel circuit with the remaining liquid lines and some liquid refrigerant will continue to flow therethrough and be available for warming the suction gas flowing through the heat exchanger from the evaporator associated with the closed valve. The continued flow of warm liquid through the heat exchanger will produce sufficient superheating of the gas to effect opening of the valve as soon as the condition has been overcome which resulted in its closing.

The arrangement described is particularly useful in air conditioning systems such as that illustrated in which the entering air is at a relatively low temperature. In the system shown in Fig. 1 a cooling coil 33 having a control valve 34 is provided in the duct 11 to cool the entering fresh air, the coil being supplied with refrigerant from any suitable source. Since the valves 27 and the heat exchangers are arranged in the duct in a relatively cool stream of air, little heat is available in the air to superheat the withdrawn vapor. The heat exchangers have therefore been shown with the warm liquid casing 28 surrounding the suction conduit and shielding it from the cooler air stream.

During the operation of the air conditioning system illustrated, the motor 15 will actuate the fan 14 and draw a mixture of fresh and recirculated air into the casing 10 from the fresh and return air ducts 11 and 13 respectively, and the mixture of air will pass over the evaporators 17 and be cooled and will thereafter be returned to the room through the discharge duct 16. The motor 19 will be energized to operate the compressor 18 whenever there is a demand for cooling in the room supplied with air by the duct 16. Under normal load conditions, the several evaporators 17 will share the load substantially equally. However, there is a possibility that one or more of the thermostatic valves 27 may close due to the lowering of the suction gas temperature to the value determined by the temperature setting of the valve. When the valve 27 of one of the evaporators closes, the liquid refrigerant flowing through the casing 28 of the corresponding heat exchanger will tend to flow through the equalizing manifold 32 and help supply liquid refrigerant to one or more of the other evaporators. There will, therefore, be some warm liquid refrigerant flowing through the heat exchanger of the evaporator although its supply valve 27 is closed and the temperature responsive element 30 will act to reopen the valve as soon as the vaporized refrigerant withdrawn from the evaporator rises to a predetermined temperature, and the valve will be opened and operation of the evaporator resumed. It will readily be apparent that as long as at least one of the valves 27 is open, there will be some flow of hot liquid refrigerant in the several heat exchangers and consequently, some heat will be available to superheat refrigerant withdrawn from the remaining evaporators and will restore the evaporators to operation without undue delay.

It frequently happens that thermostatic expansion valves of the same size and rating will be found to maintain slightly different temperatures in the evaporator. When the arrangement of heat exchangers as described above is employed, there is a tendency to make uniform the operation of a plurality of such valves, since the additional refrigerant required for one of the valves which tends to allow more refrigerant to flow to its respective evaporator will cause some additional flow of refrigerant through the heat-exchanger of an evaporator having a valve tending to allow less refrigerant to pass therethrough. The thermal element of the latter valve will therefore be actuated in accordance with a slightly higher vapor temperature than would exist were no provision made for parallel flow of the warm liquid refrigerant through the several heat exchangers and will admit more refrigerant to its evaporator. These slight differences in the characteristics of thermostatic expansion valves are noticeable particularly when the air circulated over the evaporator is at a relatively low temperature.

In Fig. 2 I have illustrated a modified form of my invention which employs a series parallel arrangement of the heat-exchangers and liquid refrigerant inlet conduits. The arrangement of the evaporators and thermostatic expansion valves in Fig. 2 is similar to that of the evaporators and valves in Fig. 1 and corresponding parts of the apparatus have been designated by the same numerals. The several liquid conduits 25 are connected to heat-exchanger casings 35 similar to the casing 28 in Fig. 1 and the outlet con-

duits 26 have portions 36 within the casings 35 which correspond to the portions 29 in Fig. 1. Liquid refrigerant is admitted to the lowermost casing 35 from the liquid connection 23, thence through a connection 37 to the middle casing 35, and to the top casing 35 through connection 38. Each of the evaporators 17 receives liquid refrigerant from its respective heat-exchanger through its corresponding liquid conduit 25. It will be apparent therefore that liquid refrigerant will flow through all of the heat-exchangers as long as the top valve 27 is open and that refrigerant will continue to flow through the casings 35 whether or not the lower valves 27 are open. Since the liquid refrigerant must pass through the lower heat-exchangers before reaching those above, it is desirable to provide progressively increased heat-exchange surfaces in the upper heat-exchangers and the casings 35 have been illustrated as of increasing length from bottom to top. The added heat-exchange surface compensates for the loss of heating capacity due to the passage of the liquid through the lower heat-exchangers. It will thus be evident that the arrangement shown in Fig. 2 is similar to that shown in Fig. 1 and that under most operating conditions one or more of the evaporators has its corresponding heat-exchanger connected in the path of liquid refrigerant flowing toward another of the evaporators so that even though the valve of the one evaporator should be closed, warm liquid refrigerant will be available in the corresponding heat-exchanger to provide the necessary super-heat of the vaporized refrigerant withdrawn from the evaporator.

From the foregoing, it is readily apparent that I have provided a simple and effective arrangement for maintaining a plurality of evaporators in operation with a single condensing unit without prolonged stopping of the operation of one or more evaporators due to the closing of their corresponding expansion valves under temporary changes in their operation.

While I have described my invention in connection with an air conditioning system in which a stream of air is cooled by a plurality of evaporators, other applications will readily be apparent to those skilled in the art, I do not, therefore, desire my invention to be limited to the construction shown and described, and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A refrigerating system including a plurality of evaporator elements, each of said elements having an inlet conduit for admitting liquid refrigerant thereto and an outlet conduit for conducting vaporized refrigerant therefrom, an inlet connection for conveying refrigerant to said inlet conduits, an outlet connection for collecting refrigerant from said outlet conduits, each of said evaporating elements having portions of its respective ones of said inlet and outlet conduits arranged in heat exchange relation, control valves for said evaporating elements arranged in the inlet conduits of their respective elements between the elements and the heat exchange portions of said inlet conduits, thermal control elements for said valves each responsive to the temperature of refrigerant withdrawn from its respective evaporating element at a position between the heat exchange portion of the respective outlet conduit and said outlet connection, and means affording circulation of liquid refrigerant

through said heat exchange portions of all of said inlet conduits during the operation of the refrigerating system regardless of the closing of any one of said valves.

2. A refrigerating system including a plurality of evaporating elements each having an inlet conduit and an outlet conduit, an inlet connection for conducting refrigerant to said inlet conduits, an outlet connection for conveying vaporized refrigerant from said outlet conduits, an equalizing manifold connecting said inlet conduits in intercommunication between said evaporating elements and said inlet connection, means arranged between said inlet connection and said equalizing manifold for transferring heat from liquid refrigerant in said inlet conduits to vaporizer refrigerant in said outlet conduits, each of said inlet conduits having a valve therein between its respective one of said evaporating elements and said equalizing manifold for controlling the flow of refrigerant to its respective evaporating element, and each of said valves including actuating means responsive to the temperature of the vaporized refrigerant in the outlet conduit of its respective evaporating element between said heat transferring means and said outlet connection.

3. A refrigerating system including a plurality of evaporators each having an inlet conduit and an outlet conduit, heat exchangers for transferring heat between the respective inlet and outlet conduits of each evaporator, each of said inlet conduits having a valve therein between its respective evaporator and heat exchanger for controlling the flow of refrigerant to its respective evaporator, each of said valves having a control element responsive to the temperature of the refrigerant vapor flowing from its respective one of said evaporators and after the passage of said vapor through the corresponding one of said heat exchangers, an inlet for conducting liquid refrigerant to said inlet conduits, an outlet for conveying vaporized refrigerant from said outlet conduits, and means affording passage of liquid refrigerant from said inlet connection through all of said heat exchangers regardless of the closing of any one of said valves.

4. A refrigerating system including a plurality of evaporators each having an inlet conduit and an outlet conduit, said conduits being arranged to provide heat exchangers for transferring heat between the respective inlet and outlet conduits of each evaporator, each of said inlet conduits having a valve therein between its respective evaporator and heat exchanger for controlling the flow of refrigerant to its respective evaporator, each of said valves having a control element responsive to the temperature of the refrigerant vapor flowing from its respective evaporator after the passage of said vapor through the corresponding one of said heat exchangers, a suction connection for withdrawing vaporized refrigerant from said outlet conduits, a liquid line for conveying refrigerant to said inlet conduits, at least one of said evaporators having its corresponding heat exchanger connected in a path of liquid refrigerant flowing toward another of said evaporators whereby closing of the valve of said one evaporator will not interrupt the heating of the vaporized refrigerant flowing from said one evaporator.

5. A refrigerating system including a plurality of evaporators each having an inlet conduit and an outlet conduit, heat exchangers for transferring heat between the respective inlet and outlet

conduits of each evaporator, each of said inlet conduits having a valve therein between its respective evaporator and heat-exchanger for controlling the flow of refrigerant to its respective
5 evaporator, each of said valves having a control element responsive to the temperature of the refrigerant vapor flowing from its respective one of said evaporators and after the passage of said vapor through the corresponding one of said
10 heat-exchangers, an outlet connection for conveying vaporized refrigerant from said outlet con-

duits, an inlet connection for conveying liquid refrigerant to said evaporators, and means connecting all of said heat-exchangers in communication in series between said inlet connection and the inlet conduit of one of said evaporators for affording a flow of liquid refrigerant through the heat-exchanger of at least one other of said evaporators whether or not the valve of said other of said evaporators is open. 5

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