

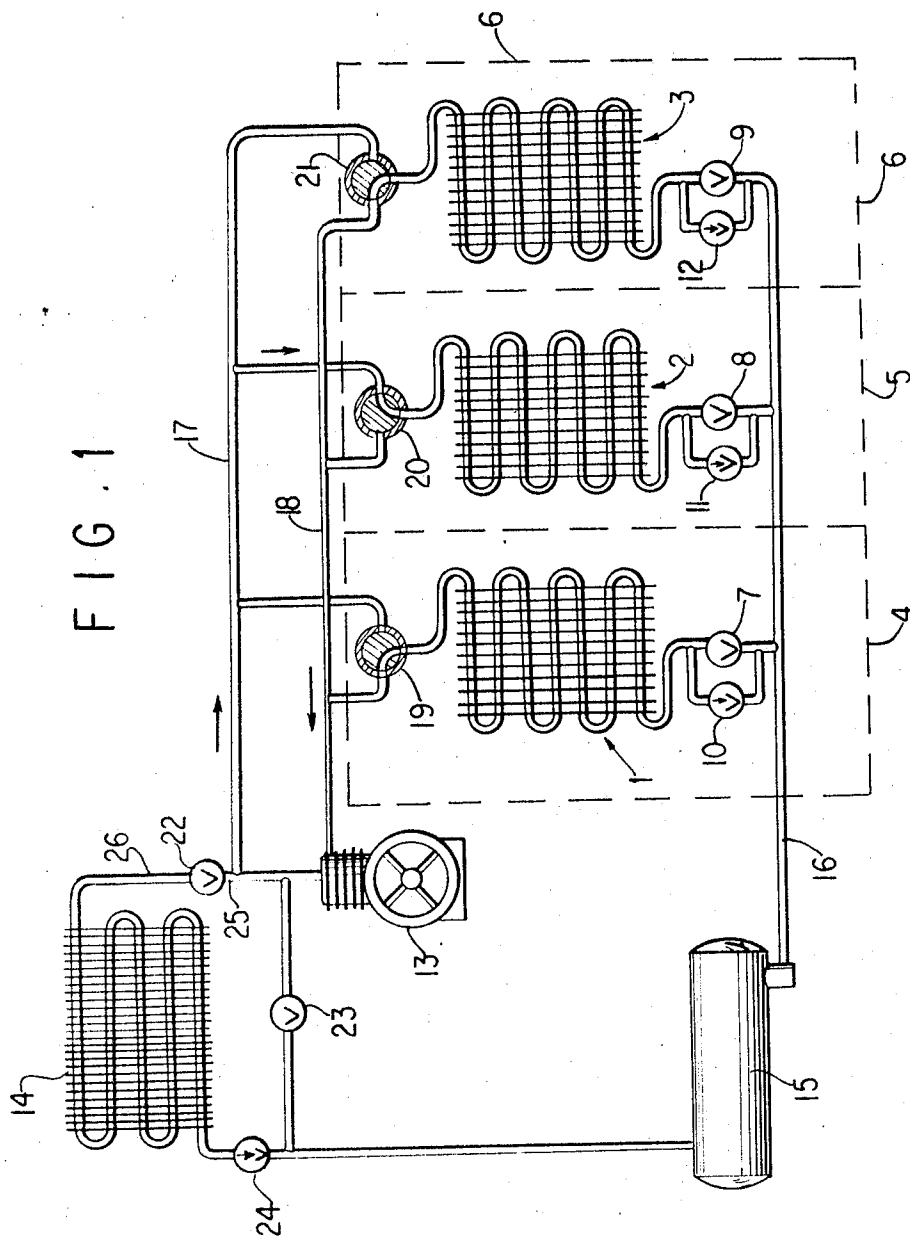
Sept. 2, 1969

D. E. KRAMER
REGENERATIVE REFRIGERATION SYSTEM WITH MEANS FOR
CONTROLLING COMPRESSOR DISCHARGE

3,464,226

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2 Sheets-Sheet 1



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FIG. 2

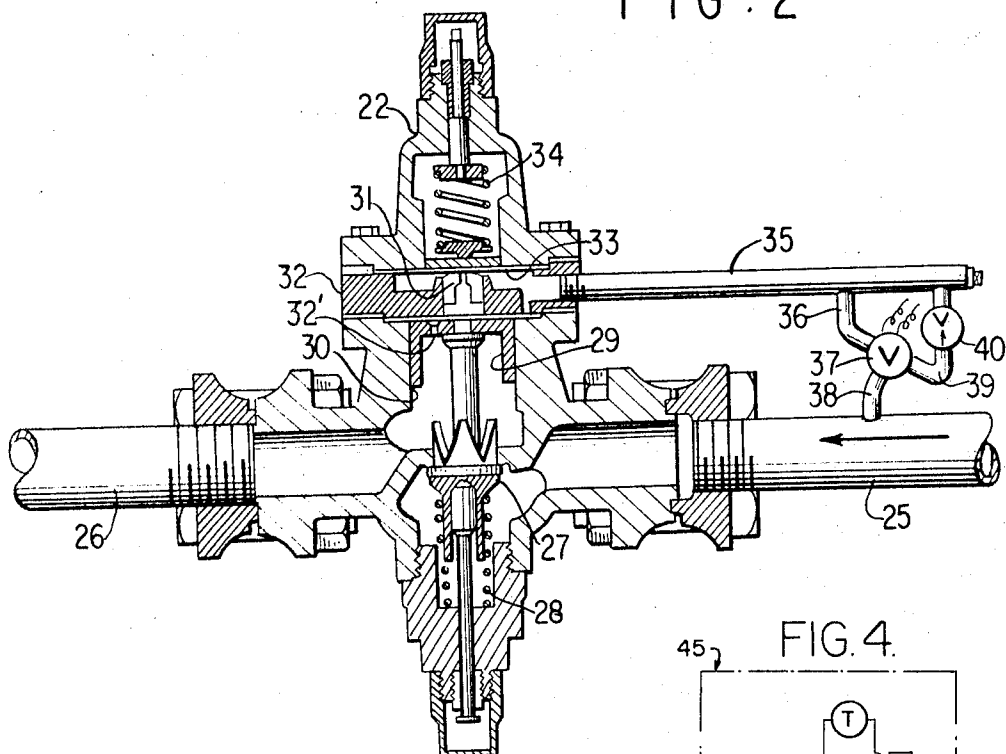


FIG. 4

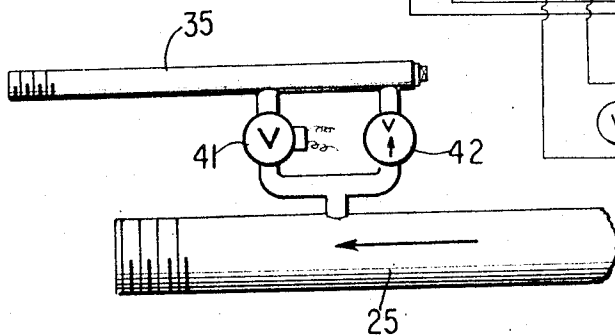
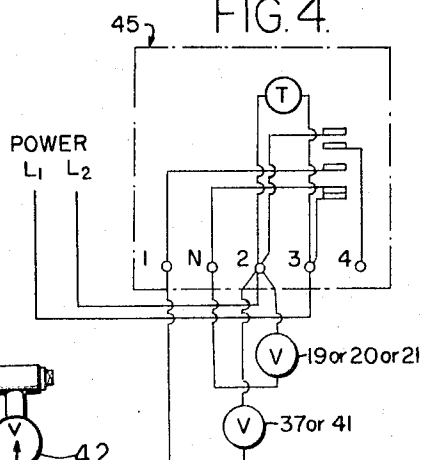


FIG. 3

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REGENERATIVE REFRIGERATION SYSTEM WITH MEANS FOR CONTROLLING COMPRESSOR DISCHARGE

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10 Claims

ABSTRACT OF THE DISCLOSURE

A regenerative refrigeration system having, as usual, a single compressor and condenser with a plurality of evaporators, arranged for the defrosting of one evaporator at a time while the other or others is or are active, and the feeding of the condensate from the evaporator being defrosted into the refrigerant supply conduit leading to the thermostatic valve or valves of the other or others, the system including means for automatically temporarily increasing the pressure of compressor discharge during defrosting to expedite the latter. In place of the single compressor there may be employed a condensing unit having a plurality of compressors constructed with a common suction conduit and a common discharge to a single condenser, e.g. U.S. Patent No. 3,140,041, dated July 7, 1964.

FIELD OF THE INVENTION

The field of the subject matter of this invention relates to the well known regenerative systems, above described, in which difficulties have been encountered in the defrosting step, particularly in regard to speed, when the condenser is elevated with respect to the evaporators as, for instance, when the former is located on the roof of a super market with the evaporators on the service floor in show cases.

SUMMARY

The present invention comprehends the provision of a regenerative refrigeration system comprising the usual members that is particularly fitted for installations in which the condenser is located in a substantially elevated position as compared with the plurality of evaporators, which may be instanced by the common practice of supermarkets and the like, where it is convenient to have the condenser on the roof of the building while the evaporators are on the ground or service floor usually in the show cases for chilled food.

As is well known to the refrigeration profession, in these regenerative systems the condensed refrigerant flowing from the evaporator that is being defrosted is fed into the supply conduit that leads to the thermostatic valves associated with the active evaporators. Thus the desired expedition of defrosting of each evaporator in turn depends not only upon the amount of heat from the compressor but importantly upon the difference in pressure between the compressor discharge and the pressure in the liquid refrigerant supply conduit for the active evaporators.

In this latter respect difficulty has been encountered when the condenser is elevated, due to the pressure of the column of condensed refrigerant in the long conduit leading downward to the usual receiver which increases the pressure in the refrigerant supply conduit for the active evaporators, with consequent slowing of the defrosting of the evaporator that is undergoing this step.

The present invention surmounts this difficulty by providing automatic means for temporarily increasing the pressure of the compressor discharge during each period of defrosting, thus counterbalancing the above described

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increase of pressure in the supply conduit and shortening the defrosting periods. The pressure of the discharge is returned to normal between defrosting periods.

BRIEF DESCRIPTION OF THE DRAWING

A practical embodiment of the invention is depicted in the accompanying drawing in which:

FIG. 1 represents diagrammatically a regenerative system comprising three evaporators, one being defrosted and the others active. The condenser is located on the roof of a building (e.g. supermarket) while the receiver may be on the lower sales service level where the refrigerated open show cases are also located, and which contain the frozen food for sale and also house the refrigerating evaporators;

FIG. 2 represents diagrammatically the means of this invention for temporarily increasing the pressure of the compressor discharge in operative association with a valve which controls discharge pressure;

FIG. 3 represents diagrammatically a detached modification of the means of FIG. 2; and

FIG. 4 represents diagrammatically a timing control means for defrosting.

In these regenerative systems, which are rapidly increasing in use especially for commercial establishments such as supermarkets and the like, it is quite desirable to have several separate evaporators positioned within service or sales fixtures, e.g. food show cases, all operated by a single compressor, condenser and receiver (or condensing unit above described), but each with its own thermostatic expansion valve or the equivalent, all of which are fed by a single refrigerant supply conduit from the condenser and receiver. Of course, the evaporators must be defrosted at intervals and a primary consideration resides in the fact that the defrosting be not only thorough, but swift in order to avoid spoiling the food within the show case where the evaporator is being defrosted.

The speed of defrosting depends on the quantity of hot gas from the compressor discharge, and greatly on the difference of pressure between the hot gas stream and the pressure in the above mentioned common liquid refrigerant supply conduit for the expansion valves of the evaporators because the condensate from the evaporator that is being defrosted drains into said supply conduit and relative increase of pressure in the latter resists the drainage and slows the defrosting by delaying the exposure of the inner surface of the evaporator undergoing defrost to the hot gas.

It will thus be clear that, when the condenser is substantially elevated with respect to the liquid refrigerant supply conduit leading to the expansion valves of the evaporators, the pressure of the column of condensate in the vertical conduit from condenser to said supply conduit will directly increase the pressure in the latter, which increase has been found to be as much as 15-20 p.s.i., and seriously prolong the defrosting step.

This problem has been solved by applicant through the incorporation in the system of pilot means for, at the period of each defrosting, automatically temporarily increasing the pressure of the compressor hot gas discharge by action upon the inlet controlled pressure valve which commonly governs compressor discharge, so as to counterbalance the above described increase of pressure in the supply conduit for the active evaporators.

Turning now to the drawing and referring to FIG. 1 that represents a whole regenerative system, there are three evaporators 1, 2 and 3, each positioned within its own fixture 4, 5 and 6, respectively, which latter are indicated in broken lines and may be assumed to be frozen food cases suitably located. Each evaporator is fitted with its own thermostatic expansion valve 7, 8 and 9, for the

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usual function; and with check valves 10, 11, 12 in pipes that by-pass the expansion valves and permit drainage of condensate during defrosting.

The compressor is denoted by 13; the condenser by 14; the receiver by 15; and the liquid supply line to the expansion valves by 16. The hot gas conduit from compressor to evaporators is marked 17 while the suction conduit leading back to the compressor has been given the reference numeral 18. Three-way solenoid valves 19, 20 and 21, respectively, serve for opening and closing communication of the evaporators with the hot gas conduit or the suction conduit according to the state of operation of the system, as will be described.

An inlet pressure regulating valve 22 controls the pressure of the compressor discharge while an outlet pressure regulating valve 23 controls the pressure in the receiver 15 and supply conduit 16 regardless of the setting of valve 22. In addition, a check valve 24 permits flow of condensate from condenser 14 to receiver 15 but prevents reverse flow. This is a known arrangement which is shown e.g. in FIG. 2 of U.S. patent to W. Micai and the present inventor, No. 2,934,911, dated May 3, 1960. Arrows indicate the direction of flow in the discharge conduit 17 and suction conduit 18.

The inlet pressure regulating valve 22 that controls compressor discharge pressure is well known to the profession in structure and function which is thought to dispense with anything more than a brief descriptive outline of its features that are pertinent to the present invention though not strictly a part thereof.

It should be noted that, while FIG. 1 shows the compressor, condenser and receiver as scattered, there may be substituted a condensing unit, above mentioned, in which the compressor, condenser and receiver are mounted on one platform, and further, that the compressor and receiver may be located indoors while the condenser is outdoors to have plenty of air, e.g., on the roof.

FIG. 2 illustrates the foregoing and the operative association of this invention therewith. This valve, of course, is formed with an inlet 25 and outlet 26 and there is a closure element 27 which establishes the extent to which the inlet and outlet are in communication and, hence, the setting of the valve in respect to control of compressor discharge pressure. This element is arranged for vertical movement and is urged upwardly toward a closed position by a spring 28. However, the movement of element 27 is governed by a piston 29 within a cylinder 30 which is formed with a port 31 in its head 32; and the piston is controlled by a diaphragm 33 which overlies the port 31 and, in turn, is under the influence of a spring 34, the effectiveness of which depends on the pressure under the diaphragm.

The result of the foregoing is that lessening of the pressure under the diaphragm will, according to its degree, permit movement of the element 27 toward a closed position and thus increase the inlet pressure setting of the valve 22 that controls the pressure of discharge from the compressor 13, this movement by the piston 29 being facilitated by a small leak orifice 32' through its top. As above noted, the essential construction and functioning of these inlet pressure controlled valves are well known and understood by the refrigeration profession so that the foregoing is deemed adequate for an understanding of this invention to be specifically described.

The substance of the invention involves an arrangement of pipes and valves therein which provides a pilot control of the pressure beneath the diaphragm 33, which arrangement is illustrated in FIG. 2 and comprises the following: a pilot inlet manifold 35 is screwed into the cylinder head 32 and opens into the space between the latter and the diaphragm 33. The manifold is connected by a pipe 36 with a three-way solenoid valve 37, which latter is in communication by another pipe 38 with the main valve inlet 25. A third pipe 39 leads from valve 37

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to the outer end of the manifold and incorporates a spring loaded check valve 40 which permits flow to the manifold but prevents reverse flow. The load on the spring of this valve may, for example, be 15 p.s.i.

Before proceeding to the operation of this assembly of pipes and valves, it seems advisable to explain that the whole matter of defrosting the evaporators in sequence, raising the pressure of hot gas defrosting during each period of defrosting and returning it to normal therebetween, and feeding the condensate from each evaporator as it is being defrosted into the liquid refrigerant supply conduit leading to the expansion valves of the active evaporators, may be controlled by an electric clock system such as is commonly used with solenoid valves and which is well known to operators and engineers in this field. A typical clock wiring diagram is shown in FIG. 4, the unit 45 being designed to turn on and off the valves controlling defrosting of a single evaporator, and as many timing units being provided as there are evaporators. By providing separate clocks, the hour and duration of each defrost cycle can be set with regard for, but independently of, the hour and duration of all other evaporators, so that the evaporators may be sequentially defrosted according to the settings of their clocks. At the start of each defrost cycle the respective 4-way solenoid valve 19 or 20 or 21 is turned to close the connection to suction line 18 and establish connection with hot gas line 17 (see valve 20 in FIG. 1), simultaneously opening 3-way solenoid valve 37 (FIG. 2, or 2-way solenoid valve 41, FIG. 3) from hot gas discharge 25 to manifold 35. At the end of the defrost cycle the valves are returned to refrigerating position.

Thus each defrosting step is timer initiated by the clock which may also terminate the defrost. The timer may be set to defrost, say, every one, two or three hours and to end the step when the period has expired, as well as to determine the spacing of the defrost of the several evaporators and the sequence of the same. The timer, of course, acts upon the several solenoid valves 19, 20 or 21.

It is also well known to terminate the defrosting steps by a thermostat sensing the temperature of a selected point on the suction conduit or at a selected point at the evaporator.

Assuming the present invention to be controlled entirely by a timer; when the time arrives for defrosting an evaporator, e.g. the one numbered 2 in FIG. 1, its valve 20 is turned to the position shown in which communication is opened to the hot gas discharge conduit 17 and closed to the suction conduit 18, while the pilot valve 37 is turned to close pipe 36 and open pipe 39 which severs the open connection of the pilot inlet manifold with the main valve inlet 25 and establishes connection of the manifold with the said inlet through the spring loaded check valve 40, thus lowering the pressure in the manifold and beneath the diaphragm 33, which permits the piston 29 to move the closing element 27 to a position that restricts the passage between the main inlet 25 and the main outlet 26 thereby increasing the pressure setting of the said valve, which is marked 22 in FIG. 1, and consequently correspondingly increasing the pressure of the compressor discharge in the hot gas conduit 17 now in open communication with the evaporator 2 and defrosting the latter.

As the defrosting proceeds, the refrigerant condensed by the melting frost on the air side of the evaporator 2 drains through the check valve 11 into the liquid supply conduit 16 which feeds the expansion valves 7 and 9 of evaporators 1 and 3 that are active, and the increase of pressure in the compressor discharge conduit 17, above explained, facilitates this drainage to speed the defrost.

At the expiration of the defrosting period according to the setting of the timer for the same, the valve 20 of evaporator 2, turns to close communication with discharge conduit 17 and open communication with suction conduit 18 to cause evaporator 2 again to become active.

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At the same time valve 37 turns to open pipe 36 which increases the pressure under diaphragm 33 and causes the piston 29 to move the closure element 27 downwardly and enlarge the passage between inlet 25 and outlet 26, thus reducing the pressure setting of the valve and simultaneously reducing the pressure in discharge conduit 17; which condition obtains until the timer for the solenoid valves initiates the defrosting of another evaporator, which step proceeds as described above in reference to evaporator 2.

The modified form of the invention presented in FIG. 3, consists merely in the substitution of a two-way solenoid valve, denoted by the reference numeral 41, for the three-way valve 37 of FIG. 2; and the substitution of an automatic outlet pressure regulating valve, marked 42, for the check valve 40 of FIG. 2, the setting of valve 42 corresponding to the setting of the spring in valve 40.

The operation of this modified form of the invention is the same as above described in connection with FIG. 2, but the use of the two-way valve 41 is more economical than the three-way, and the adjustment of the outlet pressure valve 42 is simpler than the adjustment of the spring in check valve 40 due to the fact that the valve can be externally adjusted for suitable magnitude of pressure reduction while the system is operating.

Although not shown in the drawing, as it is conventional, the water of defrost will be permitted to run off by pipe to any suitable disposal point, e.g., sewer.

It is thought that the foregoing adequately explains the value of this invention in connection with regenerative refrigeration systems, especially when the condenser is located in an elevated position relative to the evaporators, which has almost become a "must" in many commercial structures; but I desire it to be understood that various changes may be made in the parts and their arrangement without departing from the scope of the invention; and hence, I do not intend to be limited to any detail shown in the drawing or described in the specification, unless the same is recited in the claims or required by disclosures of the prior art.

What I claim is:

1. In a regenerative refrigeration system having at least one compressor, a condenser, a plurality of evaporators, a common hot gas defrost conduit for the evaporators, a common suction conduit for the evaporators, a common liquid refrigerant supply conduit for the evaporators, means for defrosting the evaporators singly, means for draining into the supply conduit the condensed refrigerant from each evaporator as it is being defrosted, and an inlet pressure regulating valve for controlling the pressure of the hot gas compressor discharge; the improvement which comprises providing means between said

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compressor and condenser for automatically increasing the pressure of the hot gas defrost discharge while an evaporator is being defrosted to accelerate the drainage of the condensed liquid refrigerant therefrom into the liquid supply conduit to the evaporators.

2. A system as defined in claim 1, in which the condenser is elevated with relation to the liquid supply conduit for the evaporators.

3. A system as defined in claim 1, in which the improvement also includes means for automatically restoring the pressure of the hot gas discharge to normal between the defrosting periods.

4. A system as defined in claim 1, in which the means for automatically increasing the pressure of the hot gas discharge comprises a pilot valve manifold operatively connected with the pressure regulating means of the inlet pressure regulating valve, a pipe connection from the said manifold to the inlet of the said valve, and a control valve in the said connection adapted to open and close the said connection.

5. A system as defined in claim 4, which also includes a second pipe connection between the manifold and the inlet of the pressure regulating valve, which second connection contains a pressure reducing device and is also in communication with the said control valve to be opened and closed as the latter closes and opens the first-named connection between the manifold and the inlet of the pressure regulating valve.

6. A system as defined in claim 5, in which the said control valve is a three-way solenoid valve.

7. A system as defined in claim 5, in which the pressure reducing device in the said second connection is a spring loaded check valve.

8. A system as defined in claim 5, in which the said control valve is a two-way solenoid valve.

9. A system as defined in claim 5, in which the pressure reducing device in the said second connection is an outlet pressure regulating valve.

10. A system as defined in claim 1, in which the means for defrosting the evaporators singly consists of automatically actuated valves adapted sequentially to open communication between each evaporator and the common hot gas defrost conduit.

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MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

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