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REFRIGERATION

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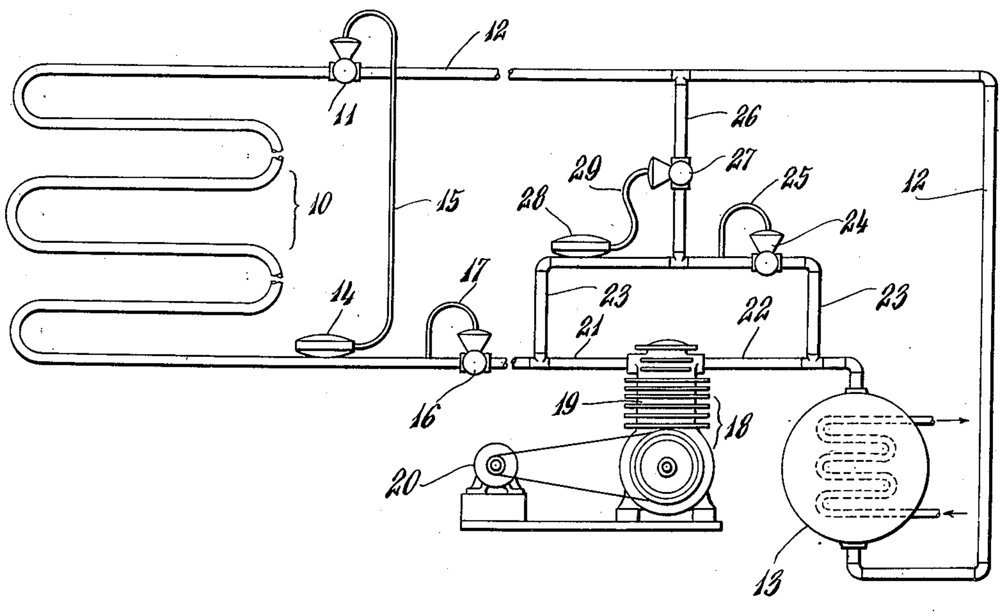

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REFRIGERATION

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5 Claims. (Cl. 62—8)

This invention relates to refrigerating systems, and, more particularly, to improvements in the arrangements for controlling the operation of such systems.

The principal object of the invention is to provide a refrigerating system which may be operated continuously to maintain a substantially constant temperature at the evaporator, regardless of whether the heat load upon that element is almost zero or is approaching the maximum for which the system was designed.

It is a further object of the invention to provide a refrigerating system in which the supply of refrigerant to the evaporator may be varied in precise accordance with the heat load imposed on that element, and in which the suction pressure of the compressor may be maintained at or above some predetermined minimum, wherefore the system as a whole may be operated continuously with its capacity modulated at any point between zero and full load conditions.

It is a more specific object of the invention to provide a refrigerating system with a by-pass through which refrigerant vapor may be circulated to maintain a minimum load on the compressor of the system whenever the load on the evaporator falls below some predetermined value, and a second by-pass through which liquid refrigerant may be bled from the condenser of the system into the suction side of the compressor, whereby to maintain the temperature of vapor which is circulated through the first-mentioned by-pass, at or below some predetermined temperature.

The foregoing and other objects of the invention will be better understood from a consideration of the following description in the light of the accompanying drawing, which illustrates diagrammatically a refrigerating system in which the features of the invention have been incorporated.

Referring to the drawing, the evaporator 10 may be of any suitable design, and may of course be employed to cool any appropriate medium to a desired final temperature. It will be assumed, for purposes of description, however, that the medium in question is air, that it passes over the surfaces of the evaporator at such widely varying temperatures as at times to impose a maximum heat load on that element, and at other times a load which is so light as to be almost negligible, and that the evaporator must function to cool that air to a substantially constant final temperature. Any suitable means may be employed to control the operation of the evaporator in such a way as to meet this last-mentioned requirement. As here shown, the control takes the form of a liquid feed valve 11 which is located in liquid line 12, and serves to regulate the quantity of liquid refrigerant admitted to the evaporator from the condenser 13 of the system in response to variations in heat load as reflected by changes in the superheat temperature of vapor leaving the evaporator.

The operation of the liquid valve is entirely conventional and need be little more than mentioned. Thus, upon an increase in the superheat of vapor leaving the evaporator, a condition which reflects an increased load on the latter element, the thermo-sensitive bulb 14 acts through control line 15 to open valve 11 and permit an increased flow of liquid refrigerant such as will meet the new load condition. Conversely, a decrease in load will be reflected by a decrease in superheat, and the bulb 14 will react to close the valve and reduce the flow of refrigerant to the evaporator.

In those cases in which a finer, more precise, control of the evaporator temperature is required, a back-pressure control may be added to the system. The control which performs this service in the illustrated system is a conventional back-pressure valve 16 located in the suction line at a point adjacent the evaporator, and having its control line 17 connected to the suction line substantially as shown. Accordingly, when the pressure in the evaporator rises above a predetermined value, this increased pressure acting upon the valve will open that element and permit an increased flow of vapor through the suction line to the compressor 18. In the event, however, that the evaporator pressure tends to fall below the set value, the valve will close to whatever extent is required to hold the back pressure, and hence the evaporator temperature, at the desired point.

It will be apparent to those familiar with the art that either one of the valves 11 and 16 will, alone, regulate the operation of the evaporator to meet variations in heat load. Either one may be dispensed with, and the system operated on the one which is retained, or both may be employed, as the needs of the particular case seem to require. It will also be evident that various other forms of control may be substituted for those which have been illustrated and described; and that all that is required by this invention is some means which will regulate the flow of refrigerant through the evaporator in accordance with variations in load on that element.

The illustrated compressor 18 is of the conventional positive displacement type in which a piston (not shown) is continuously reciprocated within cylinder 19 by an associated motor 20 whereby continuously to withdraw refrigerant vapor from evaporator 10 through suction line 21, and to compress that vapor, and simultaneously raise its temperature, so that it may flow through discharge line 22 to the condenser 13 of the system. While any other suitable form of compressor may be employed, the one shown is widely used, and serves particularly well to illustrate the utility of the invention.

It will be evident that if the evaporator is to operate continuously, the compressor must likewise operate uninterruptedly. It will also be recognized, however, that when the flow of refrigerant to the evaporator is greatly reduced, and perhaps interrupted on occasion, by the operation of valves 11 and 16, continued operation of the compressor would, in the system as so far described, serve to reduce the pressure in the suction line 21 to an undesirably low value. In order to prevent the suction pressure from falling unduly, and thus to avoid the concomitant problems of compressor shaft sealing, bearing lubrication and others with which those skilled in the art are familiar, a by-pass line 23 is connected across the suction and discharge lines 21 and 22, thus providing a path through which a controlled flow of vapor may be established whenever the normal flow from evaporator 10 is severely restricted. The control of this line is simply effected by a conventional pressure-actuated valve 24 located in the by-pass and having its control line 25 connected to the by-pass on the suction side thereof. Accordingly, when the suction pressure drops below a desired point, this low pressure acting upon the diaphragm or bellows (not shown) of the valve 24, allows that valve to open and permit a recirculation of vapor from the discharge line 22 back to the intake of the compressor. Conversely, when the suction pressure rises above the set point, it acts to hold the valve 24 closed and thus to allow operation of the system in the normal way.

It will be evident that continued recirculation of vapor through by-pass 23 will produce a cumulative heating effect which, if not offset, will result in the raising of the temperature of the vapor to a dangerously high value. In order to balance-out this heating effect, a second by-pass line 26 is connected from the liquid line 12 on the condenser side of the system to some point in the suction side of the compressor, and means are provided which will permit a controlled bleeding or injection of liquid refrigerant into the hot recirculating vapor whereby to cool that vapor to a desired degree. As here shown, this means comprises a thermo-operated liquid feed valve 27, which may be of any conventional construction, installed in the by-pass line 26 with its thermo-responsive bulb 28 secured to the suction side of by-pass line 23.

The operation of valve 27 is entirely conventional. Thus, when the superheat temperature of vapor recirculated through the first by-pass rises above a predetermined value, thermo-bulb 28 will react, through control line 29, to open valve 27 and establish a flow of liquid refrigerant into the suction side of the compressor. The liquid thus injected will immediately evaporate, thereby abstracting heat from the vapor, and cooling it to a desired degree. At that point, of course, the thermo-bulb 28 again reacts, this time tending to close valve 27, thus reducing the flow of liquid until it is just sufficient in quantity to offset the superheating of recirculated vapor above a desired temperature.

It will be noted that in the illustrated system, the liquid by-pass line 26 joins the vapor by-pass line at a point well back from the junction of the latter line with suction line 21. While this precise arrangement is not essential, it is desirable that the liquid be injected into the suction side of the compressor at such a point as to allow for its complete vaporization by the recirculated vapor whereby to avoid the passage of liquid refrigerant directly into the compressor. In this connection it will also be recognized by those familiar with the art that the thermo-responsive bulb 28 need not be located precisely as shown, but may be placed on suction line 21 or at some other appropriate point.

Those familiar with the art will recognize that the vapor and liquid by-pass lines and their associated controls, serve to establish a minimum artificial load upon the compressor whenever the normal load supplied by the evaporator is unduly low; and that this artificial loading of the compressor permits the continued operation of the system as a whole with its refrigerating effect modulated precisely in accordance with the demand upon the evaporator. They will also recognize that the various structural elements of the system, the evaporator, compressor, condenser, connecting lines, and control valves, may be of any appropriate design, and that the illustrated arrangements of these elements are entirely diagrammatic and may be varied in accordance with good engineering practice.

What I claim is:

1. A refrigerating system comprising an evaporator, a compressor, a condenser, and lines permitting a circulation of refrigerant between said elements; means for regulating the flow of liquid refrigerant from said condenser to said evaporator in response to variations in the heat load affecting the latter element; means for by-passing refrigerant vapor from the discharge side of said compressor to the inlet side thereof whereby to maintain the pressure at the inlet side above a predetermined minimum; and means for by-passing refrigerant liquid from said condenser to the inlet side of said compressor whereby to cool vapor by-passed from the discharge side of said compressor.

2. A refrigerating system comprising an evaporator, a compressor, a condenser, and refrigerant circulating lines between said elements; means for governing the flow of refrigerant through said evaporator in response to variations in heat load affecting that element; means for admitting refrigerant vapor directly from the outlet side of said compressor to the inlet side thereof responsive to the existence of a predetermined low pressure at such inlet side; and means for admitting refrigerant from said condenser directly to the inlet side of said compressor responsive to the existence of a predetermined high temperature at such inlet side.

3. A refrigerating system comprising an evaporator, a compressor, a condenser, and refrigerant circulating lines connecting said several elements; means for regulating the flow of refrigerant through said evaporator to said compressor in accordance with variations in heat load upon said evaporator; a connection between the inlet and discharge sides of said compressor, and means responding to the existence of a predetermined low pressure at such inlet side for regulating the flow of refrigerant vapor through said

connection; a connection from the condenser side of the system directly to the inlet side of said compressor, and means for regulating the flow of liquid refrigerant through said last-mentioned connection in response to the existence of a predetermined high temperature at the inlet side of said compressor.

4. A refrigerating system comprising an evaporator, a compressor, a condenser, and refrigerant circulating lines between said several elements; means for regulating the flow of liquid refrigerant from said condenser through said evaporator in response to variations in heat load upon the latter element; a conduit directly connecting the inlet and discharge sides of said compressor, a valve in said conduit, and means for actuating said valve in response to the existence of a predetermined low pressure at such inlet side; a second conduit connecting the discharge side of said condenser with the inlet side of said compressor, a second valve located in said second conduit, and means for actuating said second valve in response to the existence of a predetermined high temperature at the inlet side of said compressor.

5. A refrigerating system comprising an evaporator, a compressor, a condenser, and refrigerant circulating lines between said several elements; means for regulating the flow of liquid refrigerant from said condenser through said evaporator in response to variations in heat load upon the latter element; a conduit directly connecting the inlet and discharge sides of said compressor, a valve in said conduit, and means for actuating said valve in response to the existence of a predetermined low pressure at such inlet side; a second conduit directly connecting the condenser side of said system with said first-mentioned conduit, a valve in said second-mentioned conduit, and means for actuating said last-mentioned valve to admit liquid refrigerant from the condenser side of said system to said first-mentioned conduit responsive to the existence of a predetermined high temperature in said second conduit.

ROBERT W. WATERFILL.