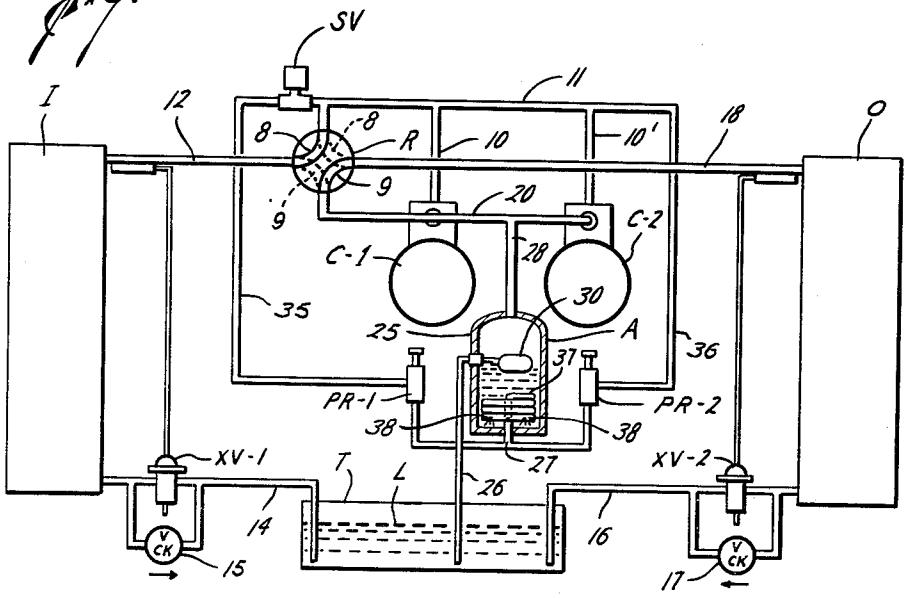
Oct. 19, 1965 R. M. HENDERSON 3,212,284

REFRIGERATION APPARATUS

Filed Feb. 28, 1964

Fig. 1



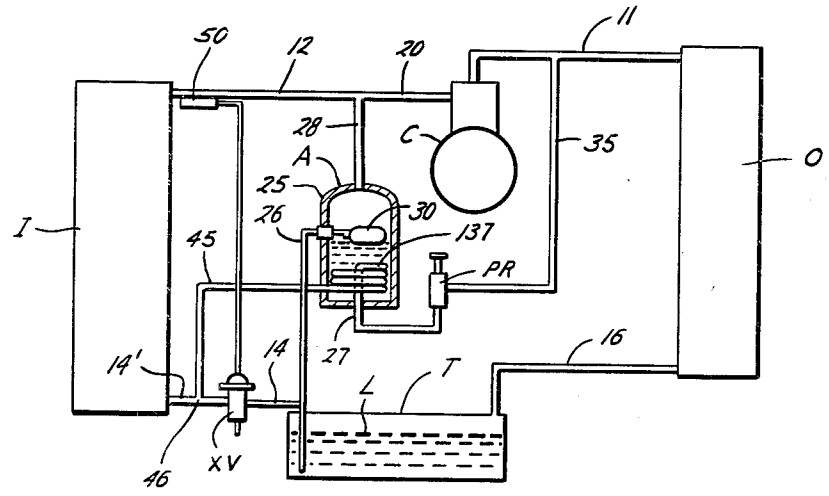


Fig. 2

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REFRIGERATION APPARATUS

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9 Claims. (Cl. 62—117)

This invention relates to new and useful improvements in refrigeration apparatus, and particularly to refrigeration apparatus suitable for use as a heat pump.

In my United States Patent 3,088,293, a refrigeration apparatus is disclosed wherein means are provided for by-passing refrigerant from the main refrigerant circuits, and for also conditioning such refrigerant prior to its return to the compressor in order to obtain effective capacity control.

It is an object of this invention to provide a new and improved apparatus having all of the advantages of the apparatus disclosed in said Patent 3,088,293, and in addition thereto, having a new and improved means for such processing and conditioning of the by-passed refrigerant.

A specific object of this invention is to provide a new and improved refrigeration apparatus which may be used as a heat pump, and which has means therewith for capacity control.

A further object of this invention is to provide a new and improved means for controlling the capacity of refrigeration apparatus, wherein such means is adapted to be used in conjunction with a conventional refrigeration circuit so that in periods of reduced loads on the refrigeration apparatus, the unused portion of the refrigerant may be by-passed and conditioned for return to the compressor means of the apparatus, while at the same time providing for the proper compressor cooling and other protective measures with respect to the refrigerant so that safe operation and proper performance is provided at all times.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

FIG. 1 is a schematic view of one form of the refrigeration apparatus of this invention, including the means for by-passing and conditioning such by-passed refrigerant; and

FIG. 2 is a schematic view of another form of the refrigeration apparatus of this invention.

In FIG. 1 of the drawings, the refrigeration apparatus is illustrated in one form for use as a heat pump. Such apparatus shown in FIG. 1 includes conventional components of a conventional refrigeration heat pump, and these include the indoor coil I, the outdoor coil O, both of which are of the typical heat exchanger construction used in refrigeration systems, and which are connected with one or more compressors C–1 and C–2 through a suitable reversing valve R. For by-passing and for conditioning the by-passed refrigerant, the new and improved apparatus of this invention includes a by-pass-conditioner unit A which functions together with a tank or receiver

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T, and other components, as will be explained more in detail, to provide for a by-passing of some of the refrigerant from the normal refrigeration circuit to thereby reduce the capacity of the apparatus when the demand for refrigeration or heat is reduced.

Considering the invention more in detail, the reversing valve R is of any conventional construction and as illustrated includes passages **8** and **9** therethrough. When the apparatus of FIG. 1 is on the heating cycle, the passages **8** and **9** are in the position illustrated in the solid lines, whereas such passages are in the positions indicated in the dotted lines when the apparatus is on the cooling cycle. The compressors C–1 and C–2 discharge gaseous refrigerant under high compression through the outlet lines **10** and **10'** to the connecting line **11** which communicates through the passage **8** of the reversing valve R with the inlet line **12** to the indoor coil I on the heating cycle. As is well understood, the gaseous refrigerant condenses in the coil I and the heat of condensation is utilized for heating a house or other enclosure. The condensed liquid in the coil I is discharged to conduit **14** through a one-way check valve **15**, by-passing the expansion valve XV–1. The condensed liquid flows from the line **14** into a receiver or tank T. The tank T is closed so that it has a level of liquid refrigerant indicated at L, with gaseous refrigerant thereabove.

In the normal circuit for the heat pump operation, the receiver T has a pipe or tube **16** extending into the liquid refrigerant within the receiver or tank T for conveying the refrigerant to the outdoor coil O for evaporation purposes. The one-way check valve **17** is closed on the heat pump cycle so that the liquid refrigerant is directed through the expansion valve XV–2 for expanding refrigerant as it enters into the outdoor coil O. The heat of evaporation is thus picked up in such expansion from the outside air on the heating cycle, in the well known manner. The gaseous refrigerant on the low side of the circuit discharges from the outdoor coil O into line **18** which flows through the passage **9** of the reversing valve R to the suction line **20** leading to both of the compressors C–1 and C–2. In the normal refrigeration and heat pump circuit, the above-described apparatus would be functioning without the unit A and could also be functioning without the tank or receiver T in some instances. In any event, the normal refrigeration apparatus used as a heat pump or as just a refrigeration system does not provide for the capacity control which is described hereinafter.

For accomplishing the capacity control, a special refrigerant conditioning unit A is provided for receiving by-passed refrigerant and conditioning same prior to the return to the compressor or compressors C–1 and C–2. In this specification and the claims, the term "by-passed refrigerant" refers to refrigerant which has been by-passed from the usual heating or cooling cycle of the refrigeration apparatus so as to reduce the capacity of the apparatus by an external unloading of the compressor or compressors.

The unit A includes a vessel **25** which is preferably closed except for liquid refrigerant inlet line **26**, gaseous refrigerant inlet line **27**, and gaseous refrigerant outlet line **28**. The liquid refrigerant inlet line **26** extends into the liquid refrigerant within the receiver or tank T so that the head of liquid and the gaseous pressure within the coil I exerts a force on the liquid within the receiver T for forc-

ing such liquid into the vessel 25 of the unit A. The level of the liquid refrigerant within the vessel 25 is maintained at a constant height by a conventional float valve 30 or any other suitable means.

The gaseous refrigerant inlet 27 is connected to the high side of the compressors through either line 35 or line 36, as will be explained. The hot gaseous refrigerant enters the inlet 27 and flows through a liquid and gaseous refrigerant transfuser 37 disposed within the liquid refrigerant inside of the vessel 25. The transfuser 37 is provided with outlets 38 in the lower part thereof for discharging refrigerant received from the inlet 27. Such discharged refrigerant fuses with the liquid refrigerant already within the vessel 25. At least a portion of the gaseous refrigerant is condensed within the transfuser 37 by reason of the heat exchange with the liquid refrigerant as the gaseous refrigerant moves within the coils of such transfuser 37. Therefore, when the refrigerant discharges from the holes 38, it is normally a mixture of gas and liquid refrigerant, although it may be entirely liquid. The combination of the reduction in pressure due to the condensation in the transfuser 37 and a distribution of the volume of flow through the several openings 38 prevents a geyser effect and excessive turbulence, or the transfer of excessively super heated gaseous refrigerant to the suction line 20 for the compressors C–1 and C–2.

The gas outlet line 28 is connected to such suction line 20 and provides for a reduced pressure within the vessel 25 above the liquid refrigerant so as to cause an ordinary refrigeration type of evaporation and so as to produce a relatively cool gaseous refrigerant which is then drawn through the line 28 and the suction line 20 into the compressors.

A valve SV which is illustrated as a solenoid-actuated valve of conventional construction is provided at the juncture between lines 11 and 35 for controlling the flow from the high side line 11 to the line 35. Such valve SV is controlled by an electrical switch (not shown) and other suitable controls of known construction (not shown) which preferably work in conjunction with the reversing valve R so that the valve SV is closed during the heating cycle and is open during the cooling cycle.

A pressure regulating valve PR–1 is located in the line 35 leading to the inlet line 27 for controlling the flow of the high side refrigerant to the unit A on the cooling cycle, as will be explained. The pressure regulating valve PR–1 is operable in response to changes in downstream or low side pressures in the apparatus and therefore has suitable pressure connections with line 12 or some other similar low side point of the apparatus, as will be well understood.

The high side line 11 is also connected with pressure control line 36 which has a pressure regulating valve PR–2 located therein. The pressure regulating valve PR–2 is, like the pressure regulating valve PR–1, of conventional construction, but it is connected for operation in response to the upstream or high side pressure of the apparatus on the heating cycle. Thus, suitable pressure connections are made from the valve PR–2 with the line 11 or other suitable high side point in the apparatus so that changes in such high side pressure are reflected at the valve PR–2 as will be more evident hereinafter. The valve PR–2 can also be adjusted to limit the rise in the high side pressures and temperatures for compressor protection during the cooling cycle.

In the operation or use of the apparatus illustrated in FIG. 1 on the heating cycle, the valve R is in the position with the solid lines indicating the valve passages 8 and 9. The valve SV is closed. So long as the system utilizes and needs the full amount of the refrigerant for delivering heat to the space being heated by the indoor coil I, there will be no by-pass of refrigerant through the line 36 to the unit A. However, when the demand for heat is reduced below that being supplied to the indoor coil I, the increase in the pressure in the high side line 11 actuates the pressure regulating valve PR–2 to open same for initiating a by-pass of some of the refrigerant through the line 36 to the unit A.

So long as the demand for heat at the indoor coil I is less than that being supplied, the pressure regulating valve PR–2 remains open, but when the demand is equal to or greater than that being supplied by the refrigerant in the indoor coil I, the pressure regulating valve PR–2 is closed.

It will be understood that if the highly super heated gaseous refrigerant were by-passed directly from the line 11 to the suction line 20 of the compressors C–1 and C–2, the heat imparted to the compressors would be so great that it might result in damage to the compressors, and in fact, experience has shown that this does result. With the present invention, the super heated gaseous refrigerant from the high side 11 is by-passed through the line 36 and then flows into the unit A so that it is cooled and conditioned for subsequent release to the suction side of the compressors. The transfuser 37 initially reduces the temperature and the volume by condensing some of the gaseous refrigerant and then discharges same into the liquid refrigerant which also is at a lower temperature than the incoming super heated gaseous refrigerant. A natural refrigeration type of evaporation occurs above the level of the liquid refrigerant in the vessel 25 and such relatively cool gaseous refrigerant is then drawn through the line 28 and the suction line 20 into the suction side of each of the compressors. In that way, all danger of overheating the compressors with the by-passed refrigerant is avoided.

On the cooling cycle, the valve SV is opened and the reversing valve R is rotated so that the passages 8 and 9 are in the dotted line positions of FIG. 1. Since the pressure regulating valve PR–1 is operable by the changes in the low pressure side of the system, the pressure regulating valve PR–1 opens when the low side pressure drops, indicating that there is more capacity for cooling at the indoor coil I than is needed. The valve PR–1 remains open so long as the excess capacity is being provided at the indoor coil I, but when the capacity becomes equal to or less than the demand at the indoor coil I for cooling, the valve PR–1 is closed. The hot gaseous refrigerant from the line 35 enters the unit A and is conditioned as previously described in connection with the flow from the line 36 so that the by-passed conditioned refrigerant is available to the compressors.

In FIG. 2, a modification is illustrated wherein the apparatus is used only for refrigeration or cooling purposes. Only a single compressor C has been illustrated, although it will be understood that a plurality of compressors, or a variable speed compressor, may be utilized, if so desired. The parts of the FIG. 2 form of the apparatus which are identical to the parts of the FIG. 1 apparatus have the same letters and/or numerals. It is noted that the high side line 11 is directed to the outdoor coil O which serves as the condenser in the usual refrigeration cycle. The refrigerant flows, after condensation in the outdoor coil O, through the flow line 16 to the receiver or tank T, and from there the refrigerant flows through the line 14 and the expansion valve XV into the indoor coil I for the refrigeration or cooling of an enclosure. The low side gaseous refrigerant returns from the indoor coil I through the line 12 to the suction side of the compressor C.

A pressure regulating valve PR which corresponds with the pressure regulating valve PR–1 of FIG. 1 is employed and it has connection through a by-pass line 35 with the high side flow line 11 for operation in the same manner as heretofore described in connection with the pressure regulating valve PR–1 of FIG. 1. The unit A for conditioning the by-pass refrigerant in FIG. 2 also functions in the same manner as the unit A of FIG. 1. The conditioned refrigerant is drawn through the line 28 and the suction line 20 into the suction side of the com-

pressor C in the same manner as heretofore described in connection with FIG. 1. Such refrigerant is in gaseous form as it passes through line **28**. However, there is a further alternative form illustrated in FIG. 2 insofar as the transfuser **137** is concerned. Such transfuser **137** is similar to the transfuser **37** of FIG. 1, except that the openings **38** are eliminated, and instead the refrigerant flows through the transfuser **137** and is discharged therefrom through outlet line **45** to the low side of the refrigerant circuit, preferably at a point **46** in the line **14'** between the expansion valve XV and the evaporator coil I.

In such alternative form, the transfuser **137** is serving as a heat exchanger without mixing the refrigerant in the coil **137** with the refrigerant within the vessel **25**. The heat exchange in the coil **137** results in a condensing of the hot gaseous refrigerant so that it becomes a properly conditioned liquid which passes through the line **45**. To prevent an excess of liquid from entering the evaporator coil I, the valve XV has a conventional temperature sensor control **50** so that should liquid fill the coil I, evaporation of the refrigerant would take place at or near the control **50**, causing it to sense an excessively low temperature which acts then to close the valve XV and prevent further flow of liquid refrigerant therethrough until the refrigerant liquid level in the coil I has returned to its normal lower level.

It will be understood that the line **45** may be connected at a point other than **46** so long as it is introduced into the low side of the refrigeration circuit at a point where liquid normally is present. Also, it should be evident that the transfuser **137** may be used in the form of the invention illustrated in FIG. 1 in lieu of the transfuser **37**, and the transfuser **37** may be used in place of the transfuser **137** in FIG. 2, depending upon the desired operating conditions.

It will be understood that in both forms of the invention, the number of compressors may be varied, and in some instances, a variable speed compressor or compressors may be employed.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. In a refrigeration apparatus having a refrigeration flow circuit with a refrigerant compressor therein, the improvement residing in means for by-passing a portion of the refrigerant normally flowing in said refrigeration flow circuit for controlling the capacity of said circuit, including:

(a) a pressure vessel,

(b) flow means connected to said pressure vessel for by-passing gaseous refrigerant from the high side of said refrigeration flow circuit to said pressure vessel,

(c) means for introducing liquid refrigerant into said vessel from said refrigeration flow circuit,

(d) inlet means to said pressure vessel disposed below the level of the liquid refrigerant therein for passing said gaseous refrigerant through said liquid refrigerant in said vessel for condensation and cooling,

(e) a gaseous refrigerant outlet separate from said inlet means and connected from said pressure vessel to the suction side of the compressor for transferring vaporized refrigerant back to said circuit in a conditioned state, and

(f) means for regulating the flow of refrigerant into said vessel.

2. In a refrigeration apparatus having a refrigeration flow circuit with a refrigerant compressor therein, the improvement residing in means for by-passing a portion of the refrigerant normally flowing in said refrigeration flow circuit for controlling the capacity of said circuit, including:

(a) a pressure vessel,

(b) flow means connected to said pressure vessel for by-passing gaseous refrigerant from the high side of said refrigeration flow circuit to said pressure vessel,

(c) means for introducing liquid refrigerant into said vessel from said refrigeration flow circuit,

(d) means for maintaining a constant level of the liquid refrigerant in said vessel,

(e) inlet means to said pressure vessel disposed below the level of the liquid refrigerant therein for passing said gaseous refrigerant through said liquid refrigerant in said vessel for condensation and cooling,

(f) a gaseous refrigerant outlet separate from said inlet means and connected from said pressure vessel to the suction side of the compressor for transferring vaporized refrigerant back to said circuit in a conditioned state, and

(g) means for regulating the flow of refrigerant into said vessel.

3. The apparatus as set forth in claim **1**, wherein a pressure regulating valve is included for regulating the flow of gaseous refrigerant into said vessel.

4. The apparatus as set forth in claim **1**, wherein at least two pressure regulating valves are included for regulating and controlling the flow of gaseous refrigerant into said vessel, and wherein one of said valves is operable in response to low side pressure of said circuit, and another of said valves is responsive to high side pressure of said circuit.

5. The apparatus as set forth in claim **2** wherein the means for controlling the liquid level is a float valve connected to the means for introducing liquid refrigerant.

6. The apparatus as set forth in claim **1**, wherein said means for passing said gaseous refrigerant includes a transfuser having a conduit connected to the gaseous refrigerant inlet and extending into the interior of the vessel below the liquid level therein.

7. The apparatus as set forth in claim **1**, including a transfuser connected to said inlet means for passing said gaseous refrigerant therethrough, said transfuser having a conduit connected to the gaseous refrigerant inlet and extending into the interior of the vessel below the liquid level therein, said conduit having outlet holes for distributing the gaseous refrigerant in said liquid refrigerant.

8. The apparatus as set forth in claim **1**, wherein said means for passing said gaseous refrigerant includes a transfuser having a conduit connected to the gaseous refrigerant inlet and extending into the interior of the vessel below the liquid level therein, said conduit being disposed in a coil within said liquid refrigerant and having discharge holes for the discharge of the refrigerant therefrom into the liquid refrigerant in said vessel for effecting cooling and condensation of the gaseous refrigerant by heat exchange with the liquid refrigerant.

9. In the operation of a compression refrigeration system having a compressor and other operating means for transferring heat with a circulating refrigerant in a main flow circuit of said system and by-pass means for by-passing and withholding a part of the refrigerant charge from circulation in said main flow circuit during said operation, the method of capacity reduction and control comprising, the first step of removing portions of the circulating refrigerant from the high side of said circuit including flows of liquid and gaseous refrigerant from different parts of said circuit, the second step of controlling the flow of liquid refrigerant from said circuit to thereby provide and maintain a controlled body of liquid refrigerant withheld from said circuit by said by-pass means, the third step of conducting the flow of gaseous refrigerant from said circuit into heat exchanging relation with said body of liquid whereby the heat transferred by said gaseous refrigerant can be used for evaporating said liquid refrigerant, the fourth step of conduct-

ing gaseous refrigerant generated by the exchange of heat between said gaseous refrigerant and said liquid to the low side of said circuit to thereby transfer refrigerant and heat from the high side to the low side of said circuit, and the additional step of regulating and controlling the flow of gaseous refrigerant through said by-pass means to thereby regulate and control the amount of refrigerant and heat transferred from the high side to the low side of said circuit by said by-pass means.

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