

July 8, 1958

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2,841,962

RETURN APPARATUS FOR A TWO-STAGE REFRIGERATION SYSTEM

Filed Jan. 23, 1957

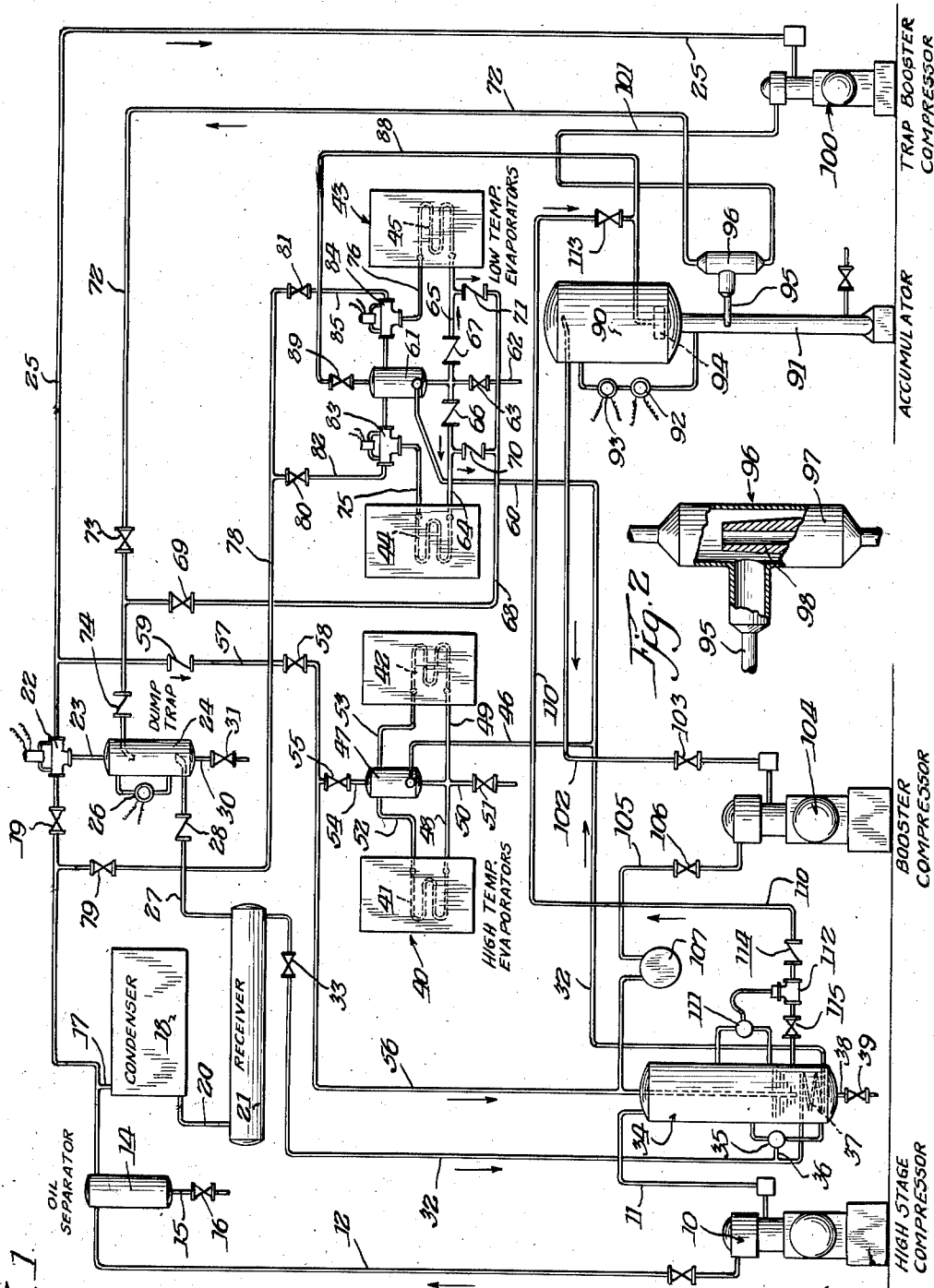


Fig. 1

Fig. 2

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RETURN APPARATUS FOR A TWO-STAGE REFRIGERATION SYSTEM

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Application January 23, 1957, Serial No. 635,859

9 Claims. (Cl. 62—174)

The invention relates to refrigeration systems of the large capacity type designed for commercial installation and has reference more particularly to an improved liquid return apparatus for a two-stage refrigeration system.

The type of refrigeration system to which the improved liquid return apparatus may be applied is characterized by high and low temperature evaporators, by a high stage compressor and by a pair of booster compressors. One booster compressor is employed for increasing the pressure of the gaseous refrigerant received from the accumulator and which is eventually delivered to the high stage compressor. The other booster compressor has connection with a liquid refrigerant dump trap for withdrawing the gaseous refrigerant from the trap and for delivering said refrigerant under pressure to an ejector, the said ejector having operation for pumping the liquid refrigerant received from the accumulator to the dump trap. One of the problems presented in the operation of a refrigeration system as described has been the protection afforded the compressor in preventing the delivery through the suction line of liquid refrigerant to the compressor either as slugs of liquid or as smaller particles of liquid entrained with the gaseous refrigerant. Accordingly an object of the invention is to provide improved liquid return apparatus for a two-stage refrigeration system of the type having a high temperature evaporator and a low temperature evaporator and wherein the apparatus will permit the continuous operation of the evaporators in a flooded condition with adequate safety to the compressor and with increased operating efficiency, all in an automatic manner, so as not to require the constant supervision of an attendant.

Another object of the invention is to provide liquid refrigerant return apparatus designed especially for a two-stage system and which will employ an accumulator in the suction line and a dump trap in the refrigerant line for handling the liquid refrigerant in a manner to collect the same in the suction line and deliver the liquid to the receiver or at some other location in the high pressure refrigerant line.

A further object is to provide apparatus as described wherein the booster compressor having connection with the dump trap is employed in conjunction with an ejector which will utilize the kinetic energy in the high pressure gaseous refrigerant from the compressor to pump liquid refrigerant received from the accumulator and for delivering the same to the trap, thus obviating the need for mechanical liquid pumps which are sometimes objectionable due to maintenance problems. However, the ejector requires little if any attention and is highly satisfactory in handling oil and two phase liquids.

Another object resides in the provision of liquid refrigerant return apparatus in combination with defrosting mechanism for one or both of the evaporators and which mechanism will make use of the dump trap as a depository for the liquid refrigerant forced from the evaporator coils during the defrosting operation. This provides savings in

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the return of useful liquid to the feed lines for use in the plant evaporators.

A more particular object of the invention is to provide defrosting mechanism as described which will utilize the heat in the gaseous refrigerant from the feed line for defrosting the evaporator coils and wherein for said purposes the delivery conduit for the evaporator coils is provided with special spring loaded check valves or gas traps so as to permit discharge of the liquid refrigerant during the defrosting operation but which will automatically hold back the flow of the gaseous refrigerant at an intermediate pressure.

A further object is to provide a suction line liquid refrigerant return apparatus wherein improved means are provided for collecting and conveniently removing oil from the several evaporators comprising the refrigerating system.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings, which illustrate an embodiment of the device and wherein like reference characters are used to designate like parts—

Figure 1 is a diagrammatic view of a refrigerating system of the two-stage type and which embodies the improved features of the present invention; and

Figure 2 is a view, parts being shown in section, of an ejector such as employed in connection with the present accumulator.

Although the improvements of the invention may be applied to refrigeration systems of various types, the system of Figure 1 has been selected for illustration. The high stage compressor designated by numeral 10 receives gaseous refrigerant at a relatively low pressure from the return conduit 11, and as a result of the pumping action of the compressor, the said gaseous refrigerant is delivered to conduit 12 at a considerably higher pressure and likewise its temperature is correspondingly increased. The high-temperature, high-pressure gaseous refrigerant is delivered by the feed line 12 to an oil separator 14 having the oil discharge pipe 15 provided with the hand valve 16 and from which the separated oil may be periodically drained. The feed line 12 has connection at 17 with the condenser 18 and the condenser in turn is joined by conduit 20 with the liquid refrigerant receiver 21. Beyond the condenser the feed line 12 connects with the two-way valve 22. Said valve is solenoid actuated and in one position thereof the valve connects the feed line 12 with conduit 23 leading to the dump trap 24 and in its second position the valve connects the dump trap through conduit with the low pressure suction line 25. The dump trap is equipped with the float switch 26 of any suitable construction and the actuation of this switch controls the solenoid valve 22. The liquid refrigerant collecting in the dump trap is delivered to receiver 21 through conduit 27, which in turn is equipped with the check valve 28, permitting flow in one direction only, that is, from the dump trap to the receiver. The pipe 30, having the hand valve 31, depends from the bottom of the dump trap and the same may be periodically opened for draining oil from the trap.

The liquid refrigerant from the receiver is conducted by conduit 32 to an intercooler tank 34. The float valve 35 for said tank has connection with conduit 32 at 36 and accordingly the tank contains liquid refrigerant at a level as determined by the float valve 35. Beyond the float valve connection the conduit 32 enters the intercooler tank and a coil is formed therefrom identified by numeral 37 and which is disposed adjacent the bottom of the tank so as to be submerged at all times in the

liquid refrigerant within the tank. The pipe 38, having the hand valve 39, is provided for draining oil from the intercooler tank. Beyond the intercooler 34 the liquid refrigerant feed line 32 provides a header for parallel connection with a pair of evaporators identified by numerals 40 and 43, the former designating the high temperature evaporators. Conduit 46 leads from the liquid refrigerant feed line 32 and has connection in turn with the surge drum 47 for the evaporator 40. Said evaporator includes cooling coils 41 and 42 having the supply conduits 48, 49, and which connect with the conduit 50, depending from the bottom of the surge drum. Conduit 50 is provided with the hand valve 51 so as to drain oil from the drum. The cooling coils of the evaporator 40 are additionally provided with a return conduit 52 and 53, respectively, and the surge drum 47 at its top has connection through pipe 54 with the suction line return conduit 56. Said return conduit enters the intercooler tank 34 and terminates below the level of the liquid refrigerant therein so that the gas and any particles of liquid refrigerant which may be returning with the gas are discharged into the liquid refrigerant within the cooling tank. The gas bubbles up through said liquid and is eventually returned to the high stage compressor 10 through the return conduit 11. Conduit 57 also has connection with conduit 56 at a point beyond the hand valve 55 and said conduit 57 connects with the low pressure suction line 25. A hand valve 53 is located in conduit 57 and there is also located in this conduit a one-way check valve 59, the same permitting flow of gaseous refrigerant in one direction only, that is, in a direction to discharge into the intermediate pressure suction line 25 during venting of the dump trap 24.

Conduit 60, in parallel with conduit 46, supplies liquid refrigerant to evaporator 43, the same conduit connecting with the surge drum 61 from which the liquid refrigerant is delivered to the cooling coils 44 and 45. The vertical conduit 62 depends from the surge drum and the supply pipes 64 and 65 connect therewith and lead to the cooling coils. Each supply pipe has a check valve such as 66 and 67, respectively, interposed therein so that the liquid will flow in one direction only, that is, toward the cooling coils. For defrosting the cooling coils a discharge conduit is provided, designated by numeral 68, and which is connected to each supply conduit through a check valve such as 70 and 71, the discharge conduit 68 in turn leading to and connecting with the supply line 72 for the dump trap. More particularly, the check valves 70 and 71 normally close during flow for refrigeration purposes although they have a special construction and which may best be described as spring loaded in a manner so as to permit discharge of the liquid refrigerant during the defrosting operation, holding back at an intermediate pressure, however, to prevent excess flow of the gaseous refrigerant past the valve. The said check valves 70 and 71 may be set for a pressure of approximately sixty pounds per square inch or somewhere within this range and it will therefore be seen that for normal operation the liquid will flow through the check valves 66 and 67 to enter and flood the evaporators with the evaporated gas escaping through the return conduits 75 and 76 and being eventually returned to the surge drum 61. Both surge drums 47 and 61 function on the order of a gas-liquid separator and said drums each include a float valve for controlling the supply of liquid refrigerant thereto and its level within the drum which is generally set at a limit to maintain the cooling coils in a flooded condition.

When operating in a manner as described the pressures on the liquid refrigerant in the supply pipes 64 and 65 are not sufficient to cause the check valves 70 and 71 to open. However, for defrosting the cooling coils the high pressure gaseous refrigerant at approximately one hundred and eighty-five pounds per square inch pressure for ammonia is admitted from the feed line 12 to the

conduit 73 by opening hand valve 79 and by opening either of the hand valves 80 and 81. Generally one cooling coil is permitted to operate while the other is being defrosted, although as regards the mechanism of the present system, both coils could be defrosted at the same time. From hand valve 80 the conduit 82 connects with the two-way valve 83 and in a similar manner valve 81 is connected with a two-way valve 84 through conduit 85. When the cooling coils are being refrigerated the two-way valves connect the return lines 75 and 76 with the surge drum 61. For a defrosting operation the two-way valves are actuated to connect the return lines 75 and 76 with the conduits 82 or 85 and thus hot gaseous refrigerant at a high pressure can be supplied to the cooling coils for defrosting them. It will be observed that the gaseous refrigerant is supplied in a direction opposite to the normal flow of the liquid refrigerant through the cooling coils and thus the check valves 66 and 67 prevent flow back to the surge drum. Since the pressures on the liquid refrigerant in the cooling coils will exceed the limit for which the special check valves 70 and 71 may have been set, the said check valves will open to allow the liquid refrigerant to flow to the dump trap. However, when the gaseous refrigerant in the cooling coils reaches the special check valves they close, thus trapping the hot gaseous refrigerant in the cooling coils for defrosting purposes. The defrosting operation for any coil may last approximately twenty to thirty minutes and the two-way valves 83 and 84 may be controlled by a time clock having operation to energize the valves alternately but only once during each twenty-four hour period.

In accordance with the present invention the surge drum 61 at its top end is provided with the low pressure return conduit 88, having the hand valve 89, and which connects with the accumulator 90 supported by the standpipe 91 and having the level responsive float switches 92 and 93 associated therewith. The gas and liquid refrigerant discharged from the end of conduit 88 is directed against a plate 94 to help evaporate the liquid. However, some liquid refrigerant will accumulate and fill standpipe 91 to which the conduit 95 is connected and this liquid will be delivered to the ejector 96, consisting of housing 97 and the internal nozzle 98. Gaseous refrigerant is supplied to nozzle 98 by the dump trap compressor 100, the gas flowing through refrigerant line 101, and which is shaped to provide a loop, thus preventing any liquid refrigerant from the ejector from flowing in a reverse direction and reaching the compressor 100. The operation of the ejector is such as to pump the liquid refrigerant received from the accumulator through the supply line 72 and said liquid together with the gas is delivered to the dump trap 24. From the trap the liquid refrigerant is periodically delivered to the receiver, whereas, the gaseous refrigerant is withdrawn through line 25 by the compressor 100 and following compression the gas is again fed to the ejector for another pumping operation.

The gaseous refrigerant collects in the top of accumulator 90 and this gas is drawn off through conduit 102, having the hand valve 103 interposed in said line. Conduit 102 has connection with the booster compressor 104 and said gaseous refrigerant in passing through the compressor has its pressure increased and is eventually delivered to conduit 105 provided with the hand valve 106. The said conduit 105 connects with an oil separator 107 which may be water cooled or refrigerated in some other manner. From the oil separator 107 the conduit 105 connects with the return conduit 56.

It may be desirable in the event of slop over in the high temperature evaporator to drain the liquid refrigerant from the intercooler tank 34 and return this liquid refrigerant to the system where it can expend its energy in cooling the evaporators. For this purpose the conduit 110 is provided, the same connecting at its left hand end

with the intercooler tank and having connection at its right hand end with the conduit 88 leading to accumulator 90. The intercooler tank is provided with the level responsive float valve 111 which in turn has connection with valve 112. When the liquid level within the intercooler tank 34 reaches the elevation of float valve 111 it causes the valve to open, admitting the liquid refrigerant to valve 112. Said valve 112 is spring urged in a closing direction and is thus normally closed. However, the effect of the liquid refrigerant from valve 111 and the difference in pressure between the intercooler and the accumulator will cause 112 to open and the liquid refrigerant above the level of float 111 will therefore be supplied to the accumulator. A check valve 114 is located to the right of valve 112 and to the left of the same there is provided a hand valve 115.

In operation of the refrigeration system as above described it will be appreciated that the dump trap in combination with the accumulator have a unique mode of operation for removing liquid refrigerant from the evaporated refrigerant returning in the suction line and which will employ the high pressure gaseous refrigerant from the feed line for periodically delivering the separated liquid refrigerant to the receiver. It has been previously explained that the dump trap will receive liquid refrigerant from the conduit 72 and during this operation the solenoid valve 22 will have a position to allow the gaseous refrigerant to return to the compressor 109 through the suction line 25. When liquid refrigerant within the dump trap reaches a predetermined level the float switch 26 will be actuated to in turn energize valve 22 and with hand valve 19 being open high pressure gaseous refrigerant from the feed line will be admitted to the dump trap to thereby force the liquid refrigerant through conduit 27 into receiver 21.

The dump trap is employed in combination with an accumulator which may have connection with one or with both of the surge drums such as 47 and 61. For purposes of illustration accumulator 90 is shown connected to surge drum 61 for the low temperature evaporator. The velocity of the gaseous refrigerant in this evaporator is particularly high and the said gaseous refrigerant thereby entrains a considerable quantity of liquid refrigerant in the form of small particles or droplets. These would be injurious if they were returned directly to the compressor and accordingly the function of the accumulator is to effect separation between the gas and the liquid with the liquid refrigerant being eventually returned by the ejector to the dump trap and the gaseous refrigerant being withdrawn from the accumulator by the booster compressor 104.

Although some liquid refrigerant will escape with the gas from the surge drum 47 the same can be taken care of in a convenient and practical manner by interposing an intercooler in the suction line 56. The intercooler performs a dual function, namely, that of cooling the refrigerant in feed line 32, for which purpose the coil 37 is provided, and also that of separating the liquid refrigerant from the gas being delivered thereto through the returning suction line 56.

Operation of the compressor 100 will be intermittent since it is controlled by the float switch 92 on the accumulator 90. When the liquid refrigerant within the accumulator reaches a preset upper limit the float switch will start operation of the compressor and the same will continue until the liquid level drops to a point causing the float switch 92 to open the circuit to the compressor motor. In the event liquid refrigerant should accumulate in 90 beyond the preset upper limit, notwithstanding the pumping action of the ejector 96, the limit switch 93 is provided as a safety since closing of this switch will sound an alarm, thereby notifying the operator of this condition.

The invention is not to be limited to or by details of construction of the particular embodiment thereof illus-

trated by the drawings, as various other forms of the device will of course be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. In a refrigerating system, the combination with a high stage compressor, cooling coils providing a high temperature evaporator and other separate and independent cooling coils providing a low temperature evaporator, of a surge drum for each of said cooling coils having operation to maintain its respective cooling coils in a flooded condition for refrigerating purposes, a high pressure refrigerant feed line from said compressor and providing parallel connections to the surge drums, a suction line for each surge drum for returning evaporated refrigerant to the compressor, the suction line for at least one of said surge drums having an accumulator interposed therein for collecting liquid refrigerant entrained with the evaporated refrigerant, a dump trap, a booster compressor for the dump trap, an ejector having connection with the accumulator for receiving liquid refrigerant therefrom, a suction return conduit connecting the top of the dump trap with the inlet to the booster compressor, a supply line connecting the outlet of the booster compressor with the ejector, conduit means connecting the ejector with the dump trap, whereby the ejector receives high pressure gaseous refrigerant from the booster compressor for pumping the liquid refrigerant received by the ejector through the conduit means for delivery to the dump trap, and other conduit means for draining the liquid refrigerant from the dump trap and delivering the same to the high pressure refrigerant feed line in advance of said parallel connections.

2. In a refrigerating system, the combination with a high stage compressor, cooling coils providing a high temperature evaporator and other separate and independent cooling coils providing a low temperature evaporator, of a surge drum for each of said cooling coils having operation to maintain its respective cooling coils in a flooded condition for refrigerating purposes, a high pressure refrigerant feed line connecting with the compressor and providing parallel connections to the surge drums for delivering liquid refrigerant to the drums respectively, a suction line for each surge drum for returning evaporated refrigerant to the compressor, the suction line of the surge drum for the low temperature evaporator having an accumulator interposed therein for collecting liquid refrigerant entrained with the evaporated refrigerant, a dump trap, a booster compressor for the dump trap and having a suction return conduit connecting the inlet of the booster compressor with the trap, an ejector in connected relation with the accumulator for receiving liquid refrigerant therefrom, a supply line connecting the outlet of the booster compressor with the ejector, conduit means connecting the ejector with the dump trap, whereby the ejector receives high pressure gaseous refrigerant from the booster compressor for pumping the liquid refrigerant received by the ejector through the conduit means for delivery to the dump trap, and other conduit means for draining the liquid refrigerant from the dump trap and delivering the same to the high pressure refrigerant feed line in advance of said parallel connections.

3. A refrigerating system as defined by claim 2, additionally including an intercooler tank interposed in the suction line of the surge drum for the high temperature evaporator, said high pressure feed line extending through the tank and providing a cooling coil therein, and said feed line having a float controlled connection with the tank in advance of the cooling coil for delivering liquid refrigerant to the tank sufficient to maintain the cooling coil in a submerged condition.

4. In a refrigerating system, the combination with a high stage compressor, cooling coils providing a high temperature evaporator and other separate and independent cooling coils providing a low temperature evaporator, of

a surge drum for each of said cooling coils, a high pressure refrigerant feed line from said compressor and providing parallel connections to the surge drums, a suction line for each surge drum for returning evaporated refrigerant to the compressor, the suction line for at least one of said surge drums having an accumulator interposed therein for collecting liquid refrigerant entrained with the evaporated refrigerant, a dump trap, a booster compressor for the dump trap and having a suction return line connecting the inlet of the booster compressor with the trap, an ejector having connection with the accumulator for receiving liquid refrigerant therefrom, a supply line connecting the outlet of the booster compressor with the ejector, conduit means connecting the ejector with the dump trap, whereby the ejector receives high pressure gaseous refrigerant from the booster compressor for pumping the liquid refrigerant received by the ejector through the conduit means for delivery to the dump trap, other conduit means for draining the liquid refrigerant from the dump trap and delivering the same to the high pressure refrigerant feed line in advance of said parallel connections, and means for introducing gaseous refrigerant from the high pressure feed line to the dump trap for forcing the liquid refrigerant therein to flow through said other conduit means.

5. In a refrigeration system, the combination with a high stage compressor, cooling coils providing a high temperature evaporator and other separate and independent cooling coils providing a low temperature evaporator, of a surge drum for each of said cooling coils, a high pressure refrigerant feed line connecting with the compressor and providing parallel connections to the surge drums for supplying liquid refrigerant to the drums, a suction line for each surge drum for returning evaporated refrigerant to the compressor, the suction line for the surge drum of the low temperature evaporator having an accumulator interposed therein for collecting liquid refrigerant entrained with the evaporated refrigerant, a dump trap, a booster compressor for the dump trap and having a suction return conduit connecting the inlet of the booster compressor with the trap, an ejector in connected relation with the accumulator for receiving liquid refrigerant therefrom, a supply line connecting the outlet of the booster compressor with the ejector, conduit means connecting the ejector with the dump trap, whereby the ejector receives high pressure gaseous refrigerant from the booster compressor for pumping the liquid refrigerant received by the ejector through the conduit means for delivery to the dump trap, other conduit means for draining the liquid refrigerant from the dump trap and delivering the same to the high pressure refrigerant feed line in advance of said parallel connections, means operable in response to changes in the level of the liquid in the dump trap, and valve means controlled by said level responsive means for closing the suction return conduit to the trap and for introducing gaseous refrigerant from the high pressure feed line to the dump trap for forcing the liquid refrigerant therein to flow to the said feed line.

6. A refrigerating system as defined by claim 5, additionally including an intercooler tank interposed in the suction line of the surge drum for the high temperature evaporator, said high pressure feed line extending through the tank and providing a cooling coil therein, and said feed line having a float controlled connection with the tank for delivering liquid refrigerant to the tank sufficient to maintain the cooling coil in submerged condition.

7. In a refrigerating system, in combination, a high stage compressor and cooling coils providing an evaporator, a surge drum in connected relation with the liquid refrigerant inlet line to the cooling coils and with the vaporized refrigerant outlet line from the coils, a high pressure refrigerant feed line connecting the compressor with the surge drum and supplying liquid refrigerant to the surge drum, a suction return line for the vaporized refrigerant, an accumulator in the suction return line for

collecting liquid refrigerant so as to prevent its delivery to the compressor, a dump trap, a booster compressor for the dump trap, a suction return conduit connecting the dump trap with the inlet to the booster compressor, an ejector having connection with the accumulator for receiving liquid refrigerant therefrom, a supply line connecting the outlet of the booster compressor with the dump trap, said ejector being interposed in the supply line whereby high pressure gaseous refrigerant is delivered to the ejector for pumping the liquid refrigerant received thereby to the dump trap, other conduit means for draining the liquid refrigerant from the dump trap and delivering the same to the high pressure refrigerant feed line, means operable in response to changes in the level of the liquid in the dump trap, and valve means controlled by said level responsive means for closing the suction return conduit to the trap and for introducing gaseous refrigerant from the high pressure feed line to the dump trap for forcing the liquid refrigerant therein to flow to the feed line.

8. A refrigerating system as defined by claim 7, additionally including defrosting means for the cooling coils, said means comprising a valve member in the outlet line from the cooling coils, said valve member in one position connecting said outlet line with the surge drum and in another position connecting the outlet line with the high pressure refrigerant feed line for introducing gaseous refrigerant to the cooling coils, a check valve in the inlet line to the cooling coils for preventing flow of liquid refrigerant in a reverse direction toward the surge drum, a conduit connecting the dump trap with the inlet line to the cooling coils at a location beyond the check valve, and a special check valve in the conduit and which opens at an intermediate pressure to permit liquid refrigerant to flow to the dump trap but which will close to prevent flow of gaseous refrigerant past said special check valve.

9. In a refrigerating system, in combination, a cooling coil providing an evaporator and having a liquid refrigerant inlet line and a vaporized refrigerant outlet line, a surge drum in connected relation with the inlet and outlet line respectively, a high pressure refrigerant feed line for delivering liquid refrigerant to the surge drum, a suction return line for the vaporized refrigerant, an accumulator in the suction return line for collecting liquid refrigerant which may entrain with the vaporized refrigerant, a dump trap, a booster compressor for the dump trap, a suction return conduit connecting the dump trap with the inlet to the booster compressor, an ejector having connection with the accumulator for receiving liquid refrigerant therefrom, a supply line connecting the outlet of the booster compressor with the dump trap, said ejector being interposed in the supply line whereby high pressure gaseous refrigerant from the booster compressor is delivered to the ejector for pumping the liquid refrigerant received thereby to the dump trap, other conduit means for draining the liquid refrigerant from the dump trap and discharging the same into the high pressure refrigerant feed line, and defrosting means for the evaporator comprising a valve member in the outlet line from the cooling coil, said valve member in one position connecting the outlet line with the surge drum and in another position connecting the outlet line with the high pressure refrigerant feed line for introducing gaseous refrigerant to the cooling coil, a check valve in the inlet line to the cooling coil for preventing flow of liquid refrigerant in a reverse direction toward the surge drum, and conduit means connecting the dump trap with the inlet line to the cooling coil at a location beyond the check valve.

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