

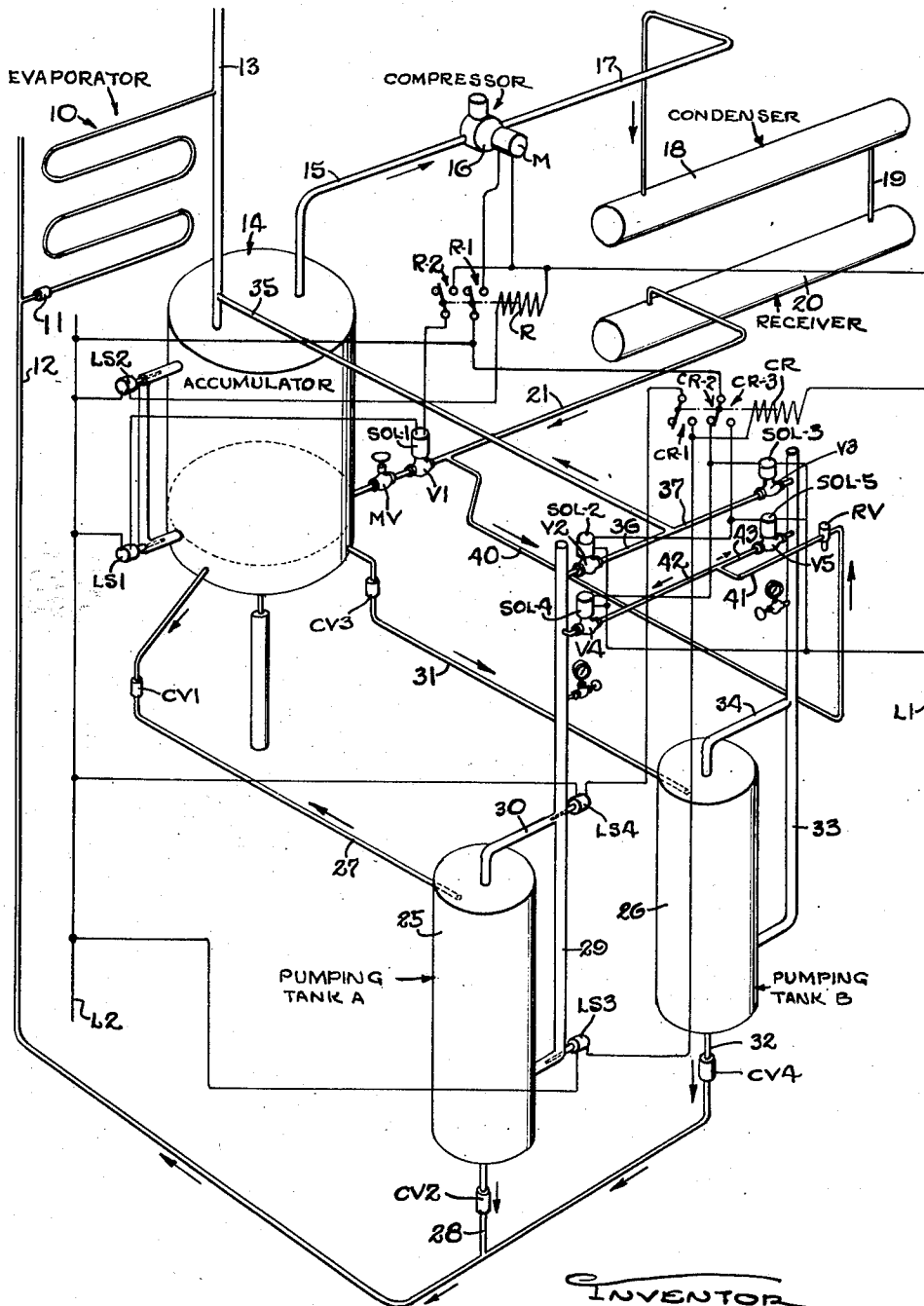
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LOW PRESSURE REFRIGERATING SYSTEMS

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## LOW PRESSURE REFRIGERATING SYSTEMS

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The invention relates to refrigerating systems generally, and more particularly to large capacity refrigerating systems suitable for commercial installation.

One object of the invention is to provide a refrigerating system of the above general character which is simpler in construction, easier and cheaper to maintain and more efficient in operation than refrigerating systems heretofore available.

Another object is to provide a refrigerating system in which flash gas entering the evaporator is minimized to insure higher coil efficiency and to permit the use of liquid lines of minimum diameter.

Another object is to provide a system in which the components are interrelated in a novel manner which reduces superheating of the spent refrigerant and enables the compressor to operate with higher volumetric efficiency and reduced power cost.

Still another object is to provide a refrigerating system in which the evaporator is continuously fed an excess of liquid refrigerant and in which the excess refrigerant is trapped and recirculated through the evaporator without requiring the usual complicated and expensive pumping equipment.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying single drawing figure.

While the invention is susceptible of various modifications and alternative constructions, a single preferred embodiment has been shown in the drawing and will be described in detail herein. There is no intention to limit the invention to the specific form disclosed but the intention is to cover all modifications and adaptations falling within the spirit and scope of the invention as more broadly or generally characterized in the appended claims.

In the exemplary refrigerating system one or more evaporator coils, of which only one coil 10 and its feed device have been shown, are connected to receive a supply of liquid refrigerant from a feed line 12. The feed device may be a conventional feed valve or a simple orifice. As the invention contemplates operation of the evaporator in a flooded condition, the feed device is adjusted or dimensioned to overfeed the evaporator, that is to supply liquid refrigerant in excess of the amount evaporated in the coil 10.

Gaseous refrigerant evaporated in the coil 10 and excess liquid refrigerant passing through the coil is carried by one section 13 of a suction line to a tank 14, usually called an accumulator. Liquid refrigerant is trapped in the accumulator while gaseous refrigerant is drawn off through the other section 15 of the suction line to the intake side of a compressor 16. The compressor is driven, in this instance, by an electric motor M.

Pressurized refrigerant gas discharged from the compressor is delivered by way of a hot gas line 17 to the condenser 18 in which the refrigerant is cooled and liquefied. The liquid refrigerant then passes by way of

a connecting line 19 to a receiver 20 in which the refrigerant is temporarily stored. The receiver thus provides a reserve capacity of liquid refrigerant. If no reserve is required, the receiver can be omitted.

In accordance with the invention the pressure of the liquid refrigerant at the high or liquid side of the system is reduced to the pressure prevailing in the suction side of the system before it is fed to the evaporator. To obtain maximum efficiency, this pressure reduction is effected in the accumulator 14 into which the liquid refrigerant from the receiver is introduced and combined with excess refrigerant passing through the evaporator. The pressure reduction effectively removes all flash gas from the liquid refrigerant and further reduces the temperature or supercools the trapped liquid refrigerant. Further, in accordance with the invention, novel means is provided for repressurizing the supercooled liquid for feeding it through the evaporator coils.

In carrying out the invention the receiver 20 is connected to the accumulator 14 by a liquid line 21. Flow of liquid to the accumulator is controlled by a valve V1 actuated by a solenoid SOL-1. A hand operated metering valve MV may be interposed between the valve V1 and the accumulator to provide for manual adjustment of the feed rate and insure smooth liquid feed.

The solenoid valve V1 is so arranged that the valve is closed when the solenoid is deenergized. In the present instance provision is made for energizing the solenoid when the liquid refrigerant in the accumulator tank falls to a predetermined level. For this purpose the accumulator tank is equipped with a level control switch LS1 having a level responsive actuator located a predetermined distance from the bottom of the tank. The switch is normally open but closes when the liquid level falls below the position in which the switch actuator is mounted. While a float device or other suitable level responsive means may be utilized for actuating the switch, the exemplary system is shown as equipped with temperature responsive level control devices of the type disclosed in my copending application, Serial No. 707,753, filed January 8, 1958.

The energizing circuit for the valve solenoid SOL-1 is also under control of a relay R which additionally controls the pump motor M. A level control switch LS2 installed near the top of the accumulator tank is effective when closed to connect the relay across the conductors L1, L2 of a power supply line. As long as the liquid level in the accumulator is below the level at which the switch LS2 is installed as it is during normal operation of the system, the switch remains closed and relay R is energized.

Relay R when energized closes switch R-1 to complete the running circuit for the pump motor M. It also closes a switch R-2 to prepare the circuit for solenoid SOL-1. If for any reason the level of liquid in the accumulator rises to the upper level responsive means, switch LS2 opens to deenergize relay R and thus stop the compressor motor. By opening the switch R-2, inadvertent energization of the valve solenoid SOL-1 and opening of the valve V1 is effectively prevented.

Liquid refrigerant collecting in the accumulator 14 drains continuously by gravity flow to one or the other of two pumping tanks 25 and 26. The tank 25 is connected to the lower end of the accumulator by a line 27. A check valve CV1 interposed in this line prevents flow of gas or liquid back to the accumulator. At its lower end the tank 25 is connected by a line 28 with the feed line 12. A check valve CV2 interposed in the line 28 prevents flow of gas or liquid from the feed line to the tank. A vertically disposed riser or pipe 29 closed at its upper end opens at its lower end to the lower portion of the tank 25. The pipe 29 also communicates

with the upper end of the tank 25 through a branch connection 30.

The pumping tank 26 is similarly connected to the lower end of the accumulator by a line 31 equipped with a check valve CV3 preventing gas or liquid flow back to the accumulator. The lower end of the tank 26 connects through a line 32 and check valve CV4 with the feed line 12. A riser or pipe 33 alongside the tank 26 opens into the lower end of the tank and communicates with the upper end of the tank through a branch connection 34. The pipe 33, of course, is closed at its upper end.

Provision is made for venting the pumping tanks 25 and 26 alternately to the suction side of the system to equalize the pressure with that in the accumulator and thus permit gravity flow of liquid refrigerant into the vented pumping tank. Such venting is effected through a vent line 35 connected at one end to the section 13 of the suction line and at the other end by branch lines 36 and 37 with the risers 29 and 33. Valves V2 and V3 in the branch lines control the opening and closing of the vent to the respective pumping tanks. The valves are respectively provided with operating solenoids SOL-2 and SOL-3.

Provision is also made for introducing pressurized gaseous refrigerant into the pumping tanks alternately to force the liquid refrigerant therein through the feed lines 12 to the evaporator. For this purpose, a branch line 40 is extended from the liquid line 21 to a pressure reducing valve RV which has its outlet connected by a line 41 and branches 42 and 43 with the risers 29 and 33, respectively. Valves V4 and V5 in the branch lines 42 and 43 control the flow of gas to the respective risers and their associated pumping tanks. Solenoids SOL-4 and SOL-5 are provided for operating the valves.

The invention provides simple yet effective control means for operating the various valves to condition the system so that the tanks 25 and 26 alternately receive liquid refrigerant from the accumulator and then discharge it under pressure to the feed line. More particularly, the valves are operated in a sequence such that when one pumping tank is being filled the other is discharging into the feed line, thus providing a continuous supply of super-cooled liquid refrigerant to the evaporator.

The controls for effecting the desired sequence of valve operations include a control relay CR and a pair of level responsive switches LS3 and LS4. These switches are installed in the riser 29 to operate in accordance with the level of liquid refrigerant in the pumping tank 25. The arrangement is such that the switches normally tend to close and open only when their associated level responsive actuating means is immersed in liquid refrigerant. Thus, the switch LS3 closes when substantially all of the liquid refrigerant is forced from the tank 25. Switch LS4 is closed until the tank 25 is completely filled.

The operation of the refrigerating system constructed and arranged in the above manner is completely automatic. Assume by way of example, that operation is proceeding with the pumping tank 25 supplying refrigerant to the feed line 12 and the evaporator. Relay CR is deenergized. Valve V2 is closed, sealing off the tank 25 from the suction line and valve V4 is open, admitting pressurized fluid to the tank to drive out the liquid refrigerant. At the same time, valve V3 is open, venting pumping tank 26 and valve V5 is closed, shutting off the flow of pressurized fluid to the tank. Liquid refrigerant accordingly flows by gravity from the accumulator 14 into the tank 26.

The above conditions prevail until the liquid level in the tank 25 falls below the level switch LS3. When that occurs, the switch closes to connect the winding of relay CR across the line conductors L1-L2. Relay CR upon energizing closes switch contacts CR-1 to complete a

holding circuit for itself by way of level switch LS4 which is closed and remains closed until the tank 25 is again filled with liquid refrigerant to the level of that switch.

The opening of switch contacts CR-2 by the relay CR interrupts the circuits for valve solenoids SOL-3 and SOL-4. Valve V3 closes to interrupt the venting of tank 26 and valve V4 closes to shut off the supply of pressurizing fluid to the tank 25. The closure of switch contacts CR-3 completes energizing circuits for valve solenoids SOL-2 and SOL-5. Valve V2 opens to vent tank 25 and thus condition it to receive liquid refrigerant by gravity flow from the accumulator. Valve V5 opens to admit pressurizing fluid to the tank 26 to force the liquid refrigerant from it through the feed line to the evaporator.

The tanks 25 and 26 and their connections are so proportioned that the filling of the tank 25 proceeds at a slightly greater rate than the emptying of the tank 26. When liquid level in the tank 25 reaches the upper level responsive device, level switch LS4 opens to interrupt the holding circuit for relay CR. The relay becomes deenergized, opens the circuits for solenoids SOL-2 and SOL-5 and closes the circuits for solenoids SOL-4 and SOL-3. Valves V2 and V5 accordingly close and valves V4 and V3 are opened. This returns the system to the condition first described with tank 26 vented and receiving liquid refrigerant from the accumulator. Tank 25, on the other hand, is sealed off from the suction line and receives pressurized gas from the reducing valve RV. Liquid refrigerant is accordingly supplied from the evaporator to the pumping tank 25.

The above sequence of operations continues with first one pumping tank supplying liquid refrigerant to the evaporator while the other tank receives a fresh supply of liquid from the accumulator. Then at the proper time the other tank takes up the feeding job while the first tank is being refilled.

The operating economies realizable with the improved system described above will be readily apparent to those skilled in the art. Power consumption is reduced to a minimum since only a small pressure differential between the high and low sides of the system is required to provide an ample flow of refrigerant through the evaporator. The compressor and the condenser can therefore be operated at the lowest pressure level that will produce the quantity of liquid refrigerant required. Furthermore, the complete removal of flash gas from the liquid refrigerant and its supercooling in the process allows the evaporator to operate at peak efficiency.

It is to be particularly noted that unusually high operating efficiency is attained without complicating the system. Actually, the plant equipment is greatly simplified. The components of the system are all of the simple, durable type which are little subject to wear and which require maintenance attention only at long intervals. mechanical pumps for circulating liquid coolant are dispensed with. Since the feed liquid is supercooled and completely freed of flash gas, the liquid and suction lines may be of minimum size. Moreover, the accumulator and pumping drums may be assembled in a compact unit and installed in the engine room close to the compressor. When so installed, superheating of the suction gas is held to a negligible amount, thus enabling the compressor to operate the maximum volumetric efficiency.

I claim as my invention:

1. In a refrigerating system including a suction line for returning gaseous refrigerant from an evaporator to a compressor and a feed line for liquid refrigerant, an accumulator tank connected to both of said lines operative to collect liquid refrigerant entrained with the gaseous refrigerant in the suction line and to flash off gas and reduce the pressure of liquid refrigerant received from the feed line, a pumping tank connected to receive accumulated liquid refrigerant from said accumulator tank,

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and connections for introducing refrigerant from said feed line into said pumping tank to force the liquid refrigerant therein to said evaporator.

2. In a refrigerating system, in combination, an evaporator, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquefy compressed refrigerant gas received from the accumulator, means including conduits operative to deliver the liquid refrigerant to said accumulator tank, a pumping tank connected to receive liquid refrigerant from said accumulator tank by gravity flow, conduit means connecting said pumping tank with the inlet side of said evaporator, and means for pressurizing said pumping tank to force the liquid refrigerant therefrom through said evaporator.

3. In a refrigerating system, in combination, an evaporator, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquefy compressed refrigerant gas received from the compressor, means including conduits operative to deliver the liquid refrigerant to said accumulator tank, a pair of pumping tanks connected to said accumulator tank for receiving liquid refrigerant therefrom by gravity flow, conduit means connecting said pumping tanks with the inlet side of said evaporator, and means for pressurizing said pumping tanks alternately to force the liquid refrigerant therein to said evaporator.

4. In a refrigerating system, in combination, an evaporator, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquefy compressed refrigerant gas received from the compressor, a receiver connected to receive and store refrigerant liquefied in said condenser, said receiver being connected to deliver liquid refrigerant to said accumulator tank, a pair of pumping tanks connected to said accumulator tank for receiving liquid refrigerant therefrom by gravity flow, conduit means connecting said pumping tanks with the inlet side of said evaporator, and means for introducing pressurized refrigerant from said receiver into said pumping tanks alternately to force the liquid refrigerant therein to said evaporator.

5. In a refrigerating system, in combination, an evaporator, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquefy compressed refrigerant gas received from the compressor, a receiver connected to receive and store refrigerant liquefied in said condenser, said receiver being connected to deliver liquid refrigerant to said accumulator tank, a pumping tank connected to receive liquid refrigerant from said accumulator tank by gravity flow, conduit means connecting said pumping tank with the inlet side of said evaporator, conduit means connecting said pumping tank to receive flashed liquid refrigerant from said receiver for forcing the liquid refrigerant in

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the pumping tank to said evaporator, and independently operable valve means controlling the flow of liquid refrigerant from said receiver to said accumulator tank and to said pumping tank.

6. In a refrigerating system, in combination, an evaporator, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquefy compressed refrigerant gas received from the compressor, a receiver connected to receive and store refrigerant liquefied in said condenser, said receiver being connected to deliver liquid refrigerant to said accumulator tank, a pair of pumping tanks connected to said accumulator tank for receiving liquid refrigerant therefrom by gravity flow, conduit means connecting said pumping tanks with the inlet side of said evaporator, conduit means connecting said pumping tanks to receive pressurized refrigerant from said receiver, and valve means operable to direct the flow of pressurized refrigerant to said pumping tanks alternately.

7. In a refrigerating system, in combination, an evaporator, a compressor, a suction line for returning spent gaseous refrigerant from the outlet side of the evaporator to the suction side of the compressor, an accumulator tank interposed in said suction line operative to separate the liquid from the gaseous refrigerant received from said evaporator, a condenser connected to receive and liquefy compressed gaseous refrigerant received from said compressor, a receiver connected to receive and store the refrigerant liquefied in said condenser, a feed line connecting said receiver with said accumulator tank, valve means in said feed line, liquid level responsive means operative to open said valve and admit liquid refrigerant from said receiver to said accumulator tank when the liquid in the tank falls below a predetermined level, the pressure of the admitted liquid being reduced to suction line pressure with a consequent removal of flash gas and supercooling of the liquid refrigerant, means for drawing off the supercooled liquid refrigerant at suction line pressure, and means for repressurizing the drained off liquid refrigerant and delivering it to the inlet side of said evaporator.

8. In a refrigerating system, in combination, an evaporator, a compressor, a suction line for returning spent gaseous refrigerant from the outlet side of the evaporator to the suction side of the compressor, an accumulator tank interposed in said suction line operative to separate the liquid from the gaseous refrigerant received from said evaporator, a condenser connected to receive and liquefy compressed gaseous refrigerant received from said compressor, a receiver connected to receive and store the refrigerant liquefied in said condenser, a feed line connecting said receiver with said accumulator tank, valve means in said feed line, liquid level responsive means operative to open said valve and admit liquid refrigerant from said receiver to said accumulator tank when the liquid in the tank falls below a predetermined level, the pressure of the admitted liquid being reduced to suction line pressure with a consequent removal of flash gas and supercooling of the liquid refrigerant, means for drawing off the supercooled liquid refrigerant at suction line pressure including a pair of auxiliary tanks having connections with said accumulator tank and with said receiver, and valve means operative to control said connections so that one tank receives liquid refrigerant from the accumulator tank while the other is pressurized by refrigerant from the receiver to force the liquid refrigerant therein to said evaporator.

9. In a refrigerating system, in combination, an evaporator, a compressor, a suction line for returning spent gaseous refrigerant from the outlet side of the evaporator

to the suction side of the compressor, an accumulator tank interposed in said suction line operative to separate the liquid from the gaseous refrigerant received from said evaporator, a condenser connected to receive and liquefy compressed gaseous refrigerant received from said compressor, a receiver connected to receive and store the refrigerant liquefied in said condenser, a feed line connecting said receiver with said accumulator tank, valve means in said feed line, control means operative to open said valve and admit liquid refrigerant to said accumulator tank as it collects in the condenser or receiver, the pressure of the admitted liquid being reduced to suction line pressure with a consequent removal of flash gas and supercooling of the liquid refrigerant, means for drawing off the supercooled liquid refrigerant at suction line pressure, and means for repressurizing the drained

off liquid refrigerant and delivering it to the inlet side of said evaporator.

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