

Feb. 3, 1959

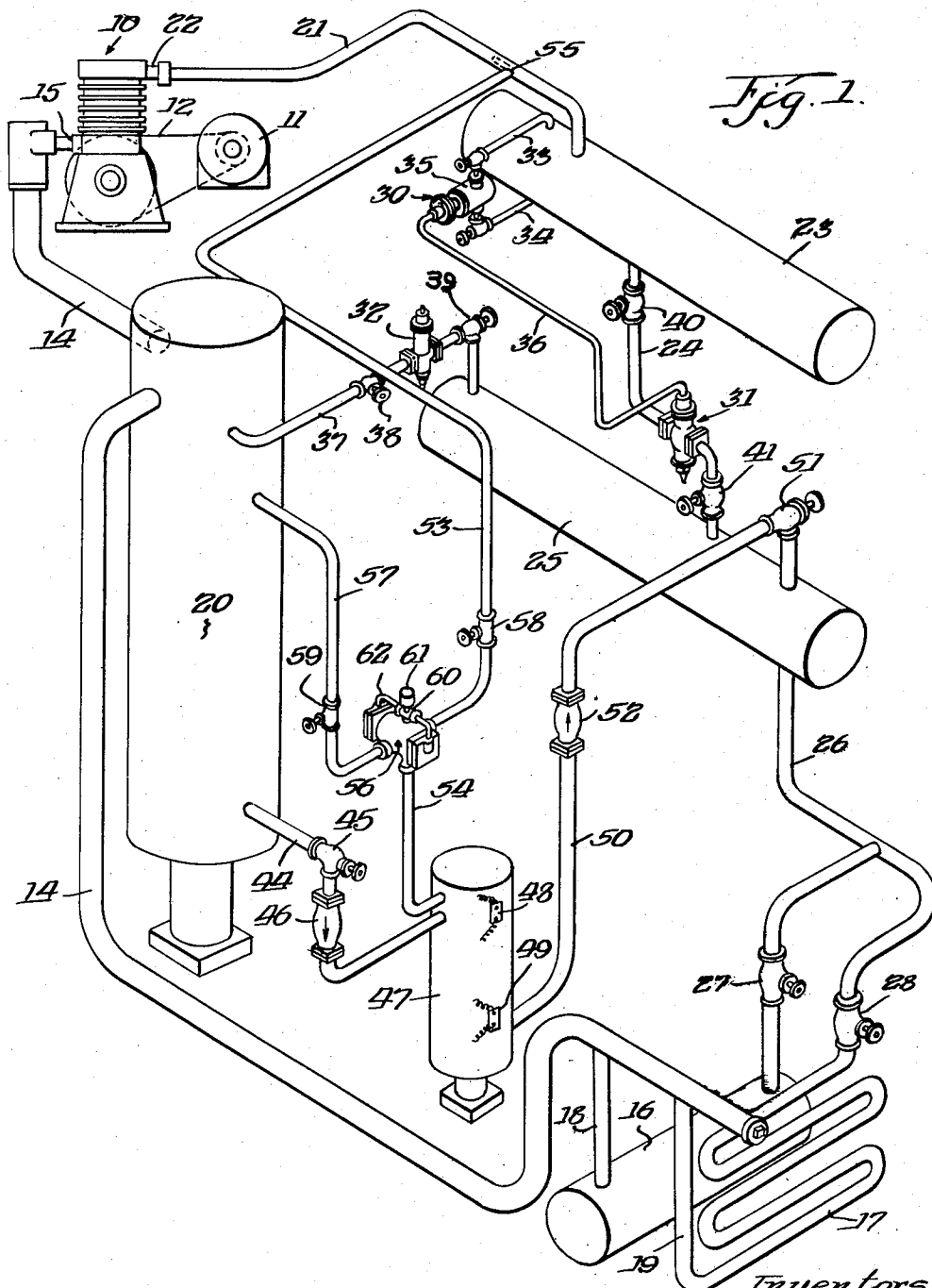
W. V. RICHARDS ET AL

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LIQUID RETURN SYSTEM

Filed Oct. 8, 1956

2 Sheets-Sheet 1



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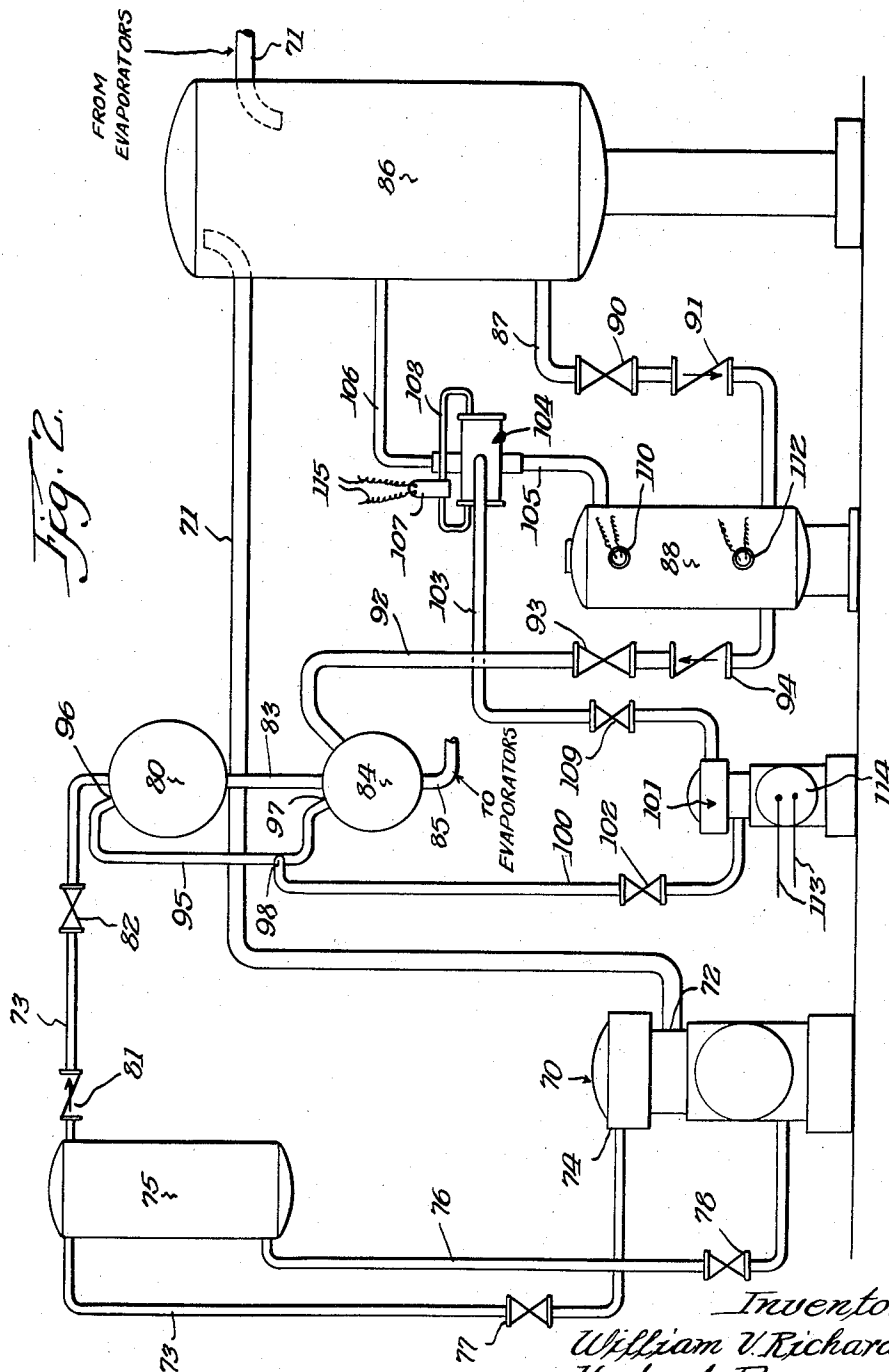
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LIQUID RETURN SYSTEM

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Application October 8, 1956, Serial No. 614,416

3 Claims. (Cl. 62—174)

The invention relates to refrigeration systems and has reference in particular to improvements especially designed for commercial installations for protecting the compressor thereof from liquid refrigerant returning in the suction line of the system when operation is such as to produce a flooded condition of the evaporators.

A basic and primary object of the invention is to provide a refrigerating system which will incorporate apparatus for accumulating the slugs of liquid refrigerant returning in the suction line from the flooded evaporators and in utilizing the refrigerant gas from the high pressure side of the system for delivering the accumulated liquid back to the high pressure side where it is available for work, to thus increase the efficiency of the system and at the same time bypassing and protecting the compressor.

Another object of the invention is to provide a suction line liquid return apparatus which will accumulate the liquid refrigerant returning in the suction line of a refrigerating system, and then utilize the high pressure refrigerant gas to deliver the liquid so accumulated to the receiver of the system, all in a manner whereby the receiver may be located on a level with the accumulator or in a plane above the accumulator.

A further object is to provide improvements for commercial refrigeration systems as described whereby a pumping of the accumulated liquid refrigerant from a trap or the like to the receiver of the system is facilitated by a pressure differential which is caused to exist between the refrigerant gas delivered to the trap and the interior of the receiver.

Still another object resides in the provision of suction line liquid return apparatus incorporating means for automatically and constantly maintaining the receiver of the system at a pressure below condenser pressure so that the liquid line pressure to the evaporators will be constant at all times, and wherein the low receiver pressure not only facilitates purging of the trap but additionally makes possible a pumping of the accumulated liquid from the trap to the receiver even though located above the trap.

Another object of the invention resides in the provision of novel improvements for incorporation in apparatus for accumulating the liquid refrigerant returning in the suction line of the system and for delivering the same to the receiver thereof, and which includes automatic means for trapping the condenser in combination with pressure regulating means for the receiver, whereby the receiver may be maintained at a pressure several pounds below condenser pressure.

Still another object resides in the provision of suction line liquid refrigerant return apparatus wherein means are provided in the form of a gas booster for boosting the pressure of the refrigerant gas to above condenser pressures before admitting the same to the trap, thereby facilitating purging of the trap, and which in addition will effect a pumping of the liquid in the trap to an elevation above the same.

With these and other objects in view, the invention

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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 invention, and wherein like reference characters are used to designate like parts:

Figure 1 is a perspective view of apparatus illustrating a refrigerating system to which the improvements of the invention have been applied; and

Figure 2 is a perspective view of a modification of the invention wherein a gas booster is employed in the refrigerant supply line delivering to the trap.

Referring to Figure 1 of the drawings which shows an embodiment of the invention, it will be seen that numeral 10 indicates a compressor of the conventional type generally employed in commercial refrigeration systems and which is driven by the electrical motor 11 by means of an endless belt 12. The suction line 14 has connection with the compressor inlet 15, and said suction line at its opposite end has connection with the evaporators 16 and 17. Numeral 16 indicates a shell evaporator, whereas 17 indicates a coil type evaporator. Either or both of these types may be employed, or they may be combined as shown and the suction outlets therefor, such as 18 and 19, have connection with the main suction line 14. In accordance with the invention, an accumulator drum 20 is interposed in the main suction line 14 for purposes which will be presently explained in detail.

The compressor 10 at its inlet end 15, accordingly receives the low pressure gaseous refrigerant from the evaporators 16 and 17, and by operation of the compressor, the pressure of this gaseous refrigerant is increased with a corresponding increase in temperature. The high pressure refrigerant side of the system is indicated by numeral 21, the same having connection with the compressor at 22 and leading to the condenser 23. The condenser discharges by gravity through line 24 into the receiver 25, and from the receiver the high pressure liquid refrigerant line 26 leads to the evaporators 16 and 17. Conventional expansion valves such as 27 and 28 are located in advance of the evaporators and which have a mode of operation well understood in the refrigerating art. The liquid refrigerant admitted to the evaporators through the respective expansion valves will evaporate in said evaporators to thus produce the desired cooling effect, and following this operation, the resulting gas is returned to the compressor through the suction line 14, thus completing the cycle.

The invention provides improved apparatus for collecting liquid refrigerant in the suction line 14 of the system and for returning the liquid to the receiver 25, thereby protecting the compressor since the same is not adapted to handle slugs of liquid refrigerant with any degree of success. More particularly, the present system employs the high-pressure refrigerant gas as a pumping medium to facilitate conveyance of the liquid refrigerant from the suction line to the receiver. Commercial refrigeration systems are operated the year round, and accordingly they are subjected to wide differences in plant receiver pressures because of variations in the outside temperatures and humidity. Variations can, therefore, be expected in the efficiency of the condensing apparatus, and since the float valves and expansion valves are thus subjected to excessive wear, their maintenance costs are correspondingly high. The above difficulties are substantially eliminated in the apparatus of the invention since the pressure within the receiver is reduced to a winter level of approximately ninety pounds per square inch for ammonia systems, for example, and held constant at all times at this lower pressure. As a result thereof the receiver provides a steady plant feed

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pressure, or, in other words the liquid line pressure at the expansion valve is maintained constant regardless of fluctuations in the condenser pressures.

The pressure differential between the receiver 25 and the condenser 23 is maintained by means of a liquid level float valve 30, a pilot operated valve 31, and a pressure regulator 32. The float valve 30 includes the top and bottom pipe connections 33 and 34 and which lead from the condenser 23 to the body 35 of the float valve. The action of the valve is to control flow of the liquid from the condenser and thus maintain the same at a desired level within the condenser. For most conditions of operation a low level of liquid refrigerant will be maintained within the condenser since it is desirable in the interest of efficiency to provide the maximum space within the condenser for performing the condensing operation on the high pressure refrigerant gas. The pressure line 36 connects the liquid level float valve 30 with the pilot operated valve 31, and thus the pilot operated valve has actuation in a manner to pass liquid refrigerant through line 24 when the liquid within the condenser is above the minimum level. When this minimum level is reached, the pilot operated valve is actuated to close. Accordingly, some liquid refrigerant is trapped at all times within the condenser. Thus when operating, the condenser will discharge its liquid refrigerant to the receiver, and it is possible to maintain the receiver at a pressure ranging from approximately two pounds below the pressure prevailing within the condenser to approximately one hundred pounds below the condenser pressure for ammonia systems.

This low pressure within the receiver 25 is maintained and regulated by a pressure regulating valve 32 which may be of conventional construction. Some gaseous refrigerant will be generated within the receiver, and this is allowed to pass off through the pressure regulating valve, being delivered by line 37 to the accumulator drum 20. This connection of the receiver 25 to the accumulator drum 20 with an interposed pressure regulating valve, has the further advantage that non-condensable gases and the like are withdrawn from the receiver. Another benefit derived from trapping the condenser is the fact that the noncondensable gases such as air will thus accumulate in the condenser and can be conveniently purged at this point either by manual means or by automatic devices. The line 37 may be provided with the hand valves 38 and 39 conveniently located on respective sides of the pressure regulating valve 32, and the line 24 may also be provided with the hand valves 40 and 41, located on respective sides of the pilot operated valve 31. The system, including the float valve 30, the pilot operated valve 31, and the pressure regulating valve 32 functions in a manner similar to a vapor or steam trap, and apparatus of this nature may be substituted therefor, provided the operation is such as to maintain the receiver at a pressure below that prevailing in the condenser. In fact, it may be possible to employ a hand valve in line 24 for developing the desired pressure differential. When such a valve is used, it is desirable to open the same to the minimum extent, and, of course, the pressure regulating valve is eliminated.

The accumulator drum is provided with an outlet pipe 44 connecting with the base of the drum and having the hand valve 45 and the check valve 46 interposed therein. Said pipe 44 connects with the trap 47 in the vicinity of the upper end thereof, and thus the liquid accumulating in the drum is able to flow by gravity through pipe 44 into the trap 47. During operation of the system, the hand valve 45 is of course open and the valve 46 is a check valve, permitting flow through the same in one direction only, that is, from the drum to the trap. It is, of course, possible to substitute a solenoid actuated valve for the check valve 46 and operate the same in a manner to drain excess liquid from the drum into the trap. The liquid refrigerant line 50 connects with the base of the trap

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47, and said line at its opposite end has connection with the receiver 25. A hand valve 51 may be interposed in the line in addition to the check valve 52 which permits flow through the line in one direction only, from the trap to the receiver. The trap 47 is equipped with electrical switches 48 and 49 which may be of the float-operated type, and which are disposed at different levels, since the same are actuated in response to changes in the liquid level within the trap.

The trap 47 is supplied with refrigerant gas from the high pressure side of the refrigerating system by means of the supply lines 53 and 54. The line 53 extends to the high pressure gaseous refrigerant supply line 21, and a tap is made with said line, as at 55, some distance in advance of the condenser 23. At the junction between lines 53 and 54, there is interposed a three-way valve designated in its entirety by numeral 56, and which has a third connection, namely, the vent pipe 57 leading therefrom and connecting with the accumulator drum 20. The supply pipe 53 may be provided with a hand valve such as 58, and a hand valve 59 is interposed in the vent line 57. The construction of the three-way valve preferably follows that as shown in the Phillips Patent No. 2,589,859 granted March 18, 1952 and entitled Suction Line Liquid Return Trap. Actuation of the valve mechanism within the three-way valve can be controlled by valve 60, which is operated electrically by the solenoid 61. The valve 60 is located in the bypass conduit 62, and in order to understand the utility of this bypass conduit, reference is made to the patent above identified.

For explaining the operation of the refrigeration system of Figure 1, it may be assumed that the system has been operating for some time, and that slugs of liquid refrigerant are being returned along with the evaporated gas in the suction line 14. The accumulator drum 20 is interposed in the suction line for the purpose of collecting and accumulating this returning liquid refrigerant. The liquid refrigerant accumulated in the drum will drain by gravity through line 44 into the trap 47, and eventually the trap will fill to the level of the switch 48. When this takes place, the switch 48 will close and thus the electrical circuit controlled by the switch is operative to energize the solenoid 61 to actuate the three-way valve 56, rendering the same operative by connecting the gaseous refrigerant supply line 53 with line 54. Automatically therewith, the vent line 57 is closed. The top of the trap 47 is thus connected with the high pressure side of the refrigerating system and the refrigerant gas at compressor discharge pressures is delivered to the trap above the liquid refrigerant therein. The action of this high pressure gas is to evacuate the trap, or, in other words, to effect a pumping of the liquid in the trap to the receiver 25. Whereas, the refrigerant gas is at compressor discharge pressures, it must be borne in mind that the receiver is maintained at a lower pressure, and thus the pumping action to evacuate the trap and deliver the liquid to the receiver is materially facilitated. In fact, it is possible to locate the receiver at a level many feet above the trap. For the maximum elevation, it may be necessary to adjust the pilot operated valve 31 and the pressure regulating valve 32 to achieve a substantial pressure difference between the condenser and receiver.

In the modification of Figure 2 the compressor for the refrigerating system is indicated by numeral 70, the same having the suction line 71 connecting therewith as at 72, and also having the high pressure gaseous refrigerant line 73 connecting with the top end of the compressor as at 74. Numeral 75 indicates an oil separator having location in the high pressure refrigerant line 73 and the oil thus separated is returned to the compressor by the line 76. The refrigerant supply line 73 may be equipped with the hand valve 77 and in a similar manner the oil return line 76 may be provided with hand valve 78. The high pressure line 73 extends from the right hand side of the oil separator 75 and eventually connects with con-

denser 80. In this section of line 73 there is interposed the check valve 81 and the hand operated valve 82. The pipe 83 connects the condenser 80 with receiver 84 and said receiver in the vicinity of its base is provided with the supply line 85 which delivers liquid refrigerant from the receiver to the evaporators of the system. The vaporized refrigerant from the evaporators together with any slugs of liquid refrigerant which may pass through the same is conducted by the suction line 71 to the accumulator drum 86. The returning liquid refrigerant is delivered to the accumulator drum and the vaporized refrigerant passes on through suction line 71 to the compressor 70, thus completing the refrigerating cycle.

The pipe 87 provides an outlet for the accumulator drum, the said pipe connecting at its opposite end with the liquid trap 88. The hand operated valve 90 and the check valve 91 are interposed in line 87 to permit flow of the liquid refrigerant from the accumulator drum to the trap and to prevent flow of said liquid in an opposite direction. The liquid trap 88 is similarly provided with an outlet pipe designated by numeral 92 and which leads to and has connection with receiver 84. The hand operated valve 93 and the check valve 94 are interposed in said line 92 and thus flow of liquid may take place in one direction only, that is, from the trap to the receiver. As previously explained and described in connection with Figure 1, the liquid refrigerant from the trap is pumped through line 92 to the receiver by using the high pressure gaseous refrigerant from the line 73 constituting the high pressure side of the system.

Whereas in the liquid return system of Figure 1 the receiver is maintained at a pressure below condenser pressure, it will be understood that in the modification of Figure 2 a gas booster is provided to boost the pressure of the refrigerant gas to above the condenser pressure before admitting the same to the trap. Accordingly, since the refrigerant gas admitted to the liquid trap is considerably above the pressures prevailing within the receiver, the liquid trap is readily evacuated and in fact the liquid may be pumped from the trap to an elevation of many feet above the same should the refrigerating system require that the receiver be elevated above the trap.

A bypass conduit 95 is provided, having connection at 96 with condenser 80 and said bypass also has connection at 97 with the receiver 84. This bypass 95 is tapped at 98 by the line 100 which in turn leads to the gas booster 101 for the liquid return system. The hand operated valve such as 102 may be located in the line 100. The gas booster 101 increases the pressure of the gaseous refrigerant tapped from the high pressure side of the system, and, following this pressure increase as regards the gaseous refrigerant, the same is delivered to the supply line 103 leading from the outlet of the gas booster 101 and connecting with the inlet of the three-way valve designated in its entirety by numeral 104. The pipe 105 constitutes the outlet for the three-way valve and said pipe connects with the top of the liquid trap 88. A third outlet for the valve 104 is provided by vent pipe 106, having connection with the accumulator drum 86. The mechanism within the three-way valve is controlled by the electrical-operated valve 107 located in bypass 108.

During operation of the refrigerating system of Figure 2 liquid refrigerant returning in the suction line 71 will be trapped and accumulated in the drum 86. From the said drum the liquid refrigerant will flow by gravity through pipe 87 to the liquid trap 88 in which said liquid is temporarily stored. When the level of the liquid within trap 88 reaches the maximum, as determined by location of the upper electric switch 110 of the float-operated liquid level type, the same is closed, thereby energizing an electric circuit controlling operation of the booster 101 and the three-way valve 104. In other words, the electric terminals 113 of the electric motor 114 for the gas booster 101 are connected to said energy source as is also the terminals 115 for the solenoid actuated valve 107. The

gas booster 101 is caused to operate to increase the pressure of the gaseous refrigerant bled off from the high pressure line 73 of the system and said gas at a materially higher pressure is then delivered to the three-way valve 104. Simultaneously with the operation of the gas booster, the valve 104 is actuated so that the vent 106 is closed off and the pipe 105 is open, thus admitting the high pressure gas to the top of the liquid trap 88. The high pressure gas will perform a pumping action on the liquid within the trap to thus evacuate the trap and pump the liquid through the line 92 to the receiver 84, thus returning the liquid to the high pressure side of the system where it is available for work.

Condenser pressures will normally prevail within receiver 84 since the same is connected with the condenser by pipe 83 and the pressures will equalize in the two cylinders. However, whatever pressure may prevail within the receiver of the refrigerating system, it will be understood that the action of the gas booster is to materially increase the pressure of the gaseous refrigerant and to boost the same to a pressure above that prevailing within the receiver. Accordingly, the desired pumping action on the liquid in trap 88 is effected and the liquid may be delivered to a receiver having an elevation of many feet above the trap. Many large refrigerating plants have a small compressor available for such use and the costs of a gas compressor is comparable to that of a liquid pump so that the economies and cost of operation of this modification of Figure 2 have been found to be satisfactory in all respects. The gas booster operates without placing an additional load on the compressor and it has the further advantage that equipment of this nature can be added to existing installations.

The apparatus of the invention will trap and recirculate liquid refrigerant in an automatic manner, thus eliminating supervision except periodic checking to ascertain the proper functioning of the various parts. As a result the cooling coils of the refrigerating system can be operated in a flooded manner to produce the maximum cooling effect with the greatest efficiency.

What is claimed is:

1. In a refrigerating system, in combination, a compressor, a suction line connected to one side of the compressor, a refrigerant feed line connected to the other side of the compressor and comprising the pressure side of the system, an accumulator drum in the suction line for trapping liquid refrigerant returning in said suction line to prevent its delivery to the compressor, a liquid trap connected to said drum for receiving the liquid refrigerant trapped in the drum and for temporarily storing said liquid, a condenser interposed in the refrigerant feed line, a receiver also located in the refrigerant feed line and positioned below the condenser, conduit means connecting the trap with the receiver, means operable in response to changes in the level of the liquid in said trap, valve means controlled by said level responsive means for periodically introducing vaporized refrigerant from the pressure side of the system into said liquid trap to force the liquid therefrom and into the receiver by way of said conduit means, float valve mechanism associated with the condenser for maintaining a predetermined level of liquid refrigerant in the condenser, and pressure regulating means for the receiver having operation to maintain a pressure in the receiver below condenser pressure to facilitate evacuation of the trap and flow of the liquid refrigerant from the trap to the receiver.

2. In a refrigeration system, in combination, a compressor, a suction line connected to one side of the compressor, a refrigerant feed line connected to the other side of the compressor and comprising the pressure side of the system, an accumulator drum in the suction line for trapping liquid refrigerant returning in said suction line to prevent its delivery to the compressor, a liquid trap located below the accumulator drum and having a valved connection with said drum for the transfer of the

trapped liquid to the trap, a condenser interposed in the refrigerant feed line, a receiver also in said line below the condenser and connecting therewith, conduit means connecting the trap with the receiver, a valve in the conduit means operable to permit flow in a direction from the trap to the receiver, electric means operable in response to changes in the level of the liquid in said trap, a solenoid valve controlled by said electric means for periodically introducing vaporized refrigerant from the pressure side of the system into said trap to force the liquid therefrom and into the receiver by way of said conduit means, other conduit means connecting the trap with the suction line and operable for venting the trap between said periodic evacuations, float valve mechanism associated with the condenser and a pilot operated valve in the connections between the condenser and receiver for maintaining a predetermined level of liquid refrigerant in the condenser, and pressure regulating means for the receiver having operation to maintain a pressure in the receiver below condenser pressure to facilitate evacuation of the trap and flow of the liquid refrigerant from the trap to the receiver.

3. In a refrigerating system, the combination with a compressor and cooling coils, of a feed line connecting the cooling coils with the pressure side of the compressor, a suction line connecting the cooling coils with the suction side of the compressor, an accumulator drum in the suction line for trapping liquid refrigerant returning in said suction line, a condenser interposed in the feed line, a receiver also located in the feed line

beyond the condenser so that liquid refrigerant from the condenser will flow into the receiver, a liquid trap for receiving and temporarily storing the liquid trapped in said accumulator drum, conduit means connecting the bottom of the trap with the receiver, means operable in response to changes in the level of the liquid in said trap, valve means controlled by said level responsive means for supplying vaporized refrigerant from the pressure side of the system to said trap to force the liquid therefrom and into the receiver by way of said conduit means, means associated with the condenser and located in the connections between the condenser and receiver for trapping the gases within the condenser while permitting the liquid to drain to a predetermined condenser level, and pressure regulating means for the receiver, said pressure regulating means connecting with the accumulator drum and operating in a manner whereby a steady pressure below condenser pressure is maintained in the receiver to assure uniform plant feed and to additionally facilitate evacuation of the trap and flow of the liquid refrigerant from the trap to the receiver.

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