

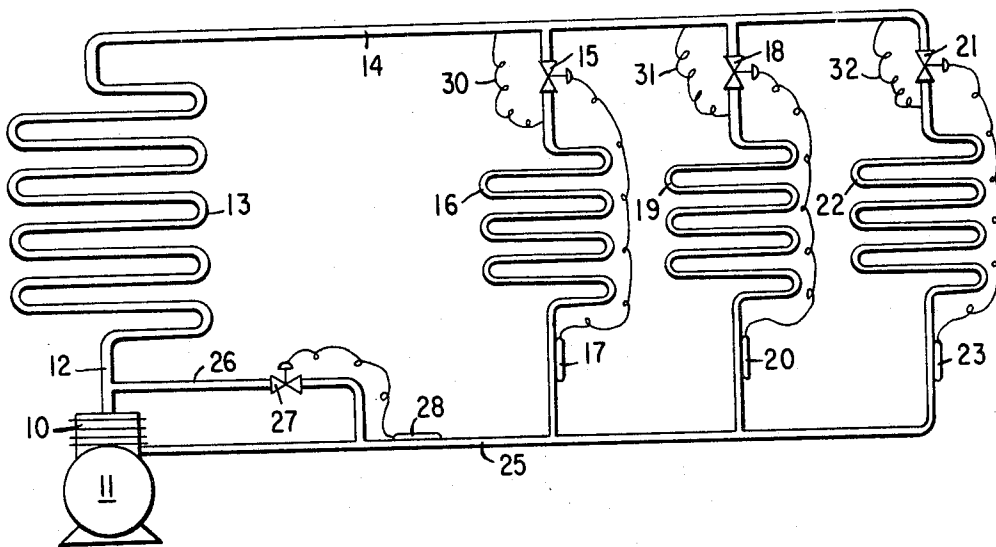
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MULTIPLE EVAPORATOR REFRIGERATION SYSTEMS

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3,390,540 MULTIPLE EVAPORATOR REFRIGERATION SYSTEMS

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This application relates to refrigeration systems, and more particularly, to refrigeration systems of the type which employ a single condensing unit and a plurality of evaporators to which refrigerant is metered by a plurality of variable orifice expansion valves.

Refrigeration systems of the type described above are desirably employed to reduce the cost of air conditioning or refrigeration in multiple evaporator units by providing a single condenser and a single compressor to serve each of the evaporators.

In such systems, it often happens that many or all of the evaporators are lightly loaded and their associated expansion valves are nearly or completely closed. Under these conditions, the compressor and condenser have greatly excessive capacity compared to the demand made by the evaporators. Consequently, the refrigerant compressor attempts to pull the system down to an excessively low suction pressure or temperature which may be injurious to the compressor and which often causes the accumulation of ice on the evaporators resulting in poor system performance and a melting problem.

In order to overcome these objections, a hot gas bypass line with a bypass valve may be provided to bypass gas from the discharge to the inlet of the compressor, thereby providing an artificial load on the compressor to prevent the suction pressure from becoming excessively low. The bypass line and valve are arranged so that when the suction pressure drops below a predetermined value, the bypass valve opens to permit a portion of the hot compressed refrigerant gas discharged from the compressor to be admitted to the suction inlet of the compressor. This arrangement prevents the suction pressure from dropping to a point where icing of the evaporators occurs.

While such systems operate satisfactorily, two problems may arise because of insufficient refrigerant circulating in the system. The first problem arises because the compressor motor often depends on the passage of cold refrigerant vapor from the evaporators for cooling the motor. When the bypass valve is open and the expansion valves are closed, little, if any, cold refrigerant vapor enters the compressor and there is a danger of motor failure due to the insufficient cooling. The other problem arises because the refrigerant compressor is often lubricated by a small quantity of oil which is deliberately circulated in the system along with refrigerant. When the bypass valve is open and the expansion valves are closed, this oil is not circulated and it tends to settle out in the evaporators or suction lines having traps where oil cannot flow by gravity or force of refrigerant flow. Consequently, the compressor may fail due to insufficient lubrication of the connecting rods or the main bearings. Similarly, if there is a leak in the system, these problems may also occur due to refrigerant leakage.

It is a principal object of this invention to provide a refrigeration system of the type employing a single condensing unit and multiple evaporators which overcomes the foregoing problems.

In accordance with this invention, there is provided a refrigeration system having a condensing unit including a compressor and a condenser. The condensing unit is connected to a plurality of evaporators having associated therewith a plurality of variable orifice expansion valves. A hot gas bypass passage and a suitably controlled bypass valve are provided to pass hot gas from the discharge

of the compressor into the inlet thereof when the suction pressure drops to a predetermined minimum pressure. A restricted bypass passage such as a capillary tube is provided to bypass refrigerant from the outlet of the condenser to the low pressure side of the system so that cold refrigerant gas and lubricant is available to the compressor even when the variable orifice expansion valves are in a relatively restricted or closed position, so that compressor lubrication and motor cooling are always available to the compressor and its motor.

These and other objects of this invention will become apparent by reference to the following specification and attached drawing which schematically shows a multiple evaporator refrigeration system according to this invention.

Referring to the drawing, there is shown a refrigeration system of the multiple evaporator type such as might be used for air conditioning an apartment house or motel. A single compressor 10 driven by electric motor 11 has an outlet which is connected by hot gas discharge line 12 to the inlet of a condenser 13. These components make up what is generally referred to as a condensing unit, and they are often disposed in a single enclosure which may be located on a rooftop or other suitable location. Air is passed over condenser 13 in order to remove heat from and to liquefy the refrigerant vapor discharged from compressor 10. The liquefied refrigerant is discharged from the outlet of the condenser through refrigerant liquid line 14.

The liquid refrigerant is then distributed from liquid line 14 to a plurality of evaporators, disposed in suitable locations which are to be cooled or air conditioned. The liquid refrigerant passes from liquid line 14, through thermal expansion valve 15, into evaporator 16. A variable orifice, thermal expansion valve 15, is provided with a suitable temperature sensitive bulb 17 on the outlet of evaporator 16 to govern refrigerant flow to the evaporator in response to superheat sensed at the outlet thereof. Similarly, a thermal expansion valve 18, associated evaporator 19 and bulb 30; and a thermal expansion valve 21, associated evaporator 22 and bulb 23 are provided to control the refrigeration capacity of evaporators 19 and 22. For purposes of illustration, three evaporators and their associated series-connected thermal expansion valves disposed ahead of the evaporators have been shown in the drawing, but it will be understood that in practice, any number of evaporators might actually be employed in the multiple evaporator refrigeration system described.

The refrigerant which is passed to evaporators 16, 19 and 22 by their associated thermal expansion valves is evaporated therein, thereby producing the desired cooling effect for each of the locations to be cooled. The refrigerant vapor evaporated in the evaporators then passes through suction line 25 to the inlet of compressor 10. If the locations to be cooled require only a relatively small amount of cooling to provide the desired temperature, the existence of cold liquid refrigerant at the outlet of the evaporator will be sensed by the proper thermal expansion valve bulb such as bulb 17 of expansion valve 15. The bulb will then reduce the pressure on a diaphragm in thermal expansion valve 15 and move the valve toward closed position so that less refrigerant is supplied to evaporator 16.

A hot gas bypass line 26 having a hot gas bypass valve 27 therein is provided to bypass hot gas around compressor 10. A bulb 28 connected to bypass valve 27 is disposed on suction line 25. In operation, when bulb 28 senses that the suction pressure or temperature has reached a predetermined minimum desired value, the pressure on a diaphragm in valve 27 is reduced to open the bypass valve. When bypass valve 27 is opened, a portion of the hot gas

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discharged from compressor 10 is bypassed back to the inlet of compressor 10 through bypass line 26, valve 27 and suction line 25.

It will be seen that the provision of hot gas bypass line 26 and valve 27 prevents the suction pressure in line 25 and at the outlet of evaporators 16, 19, 22 from becoming undesirably low by placing an artificial load on compressor 10. Consequently, the difficulty of icing of the evaporators, which is often caused by the evaporator temperature dropping so low that moisture is condensed and frozen on the cold outside surface of the evaporator, is overcome by raising the suction pressure when hot gas is bypassed.

However, as previously explained, closing of expansion valves 15, 18 and 21, or any substantial restriction of the refrigerant through the evaporators, will result in insufficient refrigerant being circulated through the system. Thus, compressor motor 11 may overheat due to insufficient cooling by cold gas returning from the evaporators and bypassing hot gas around the compressor tends to seriously aggravate the problem by heating the motor. Also, the lubricating oil has a tendency to settle out in evaporators 16, 19, 22 and parts of suction line 25 and is not properly circulated to the compressor bearings which may result in their failure when the expansion valves are closed.

These difficulties are overcome by providing a restricted bypass passage around one or more of the thermal expansion valves in order to bypass some refrigerant from the outlet of condenser 13 to the low pressure side of the system, at least during times when the expansion valves are in a relatively closed position and hot gas bypass valve 27 is open. As shown in the drawing, a restricted capillary bypass tube 30 bypasses some liquid refrigerant around expansion valve 15, a restricted capillary bypass tube 31 bypasses liquid refrigerant around expansion valve 18, and a restricted capillary bypass tube 32 bypasses liquid refrigerant around expansion valve 21. Thus, a small quantity of refrigerant, sufficient to maintain adequate motor cooling and compressor lubrication, is always circulated through the system. It will be understood that the bypass passages shown in the drawing may take other forms, may be otherwise located with respect to the evaporators, or may be built into the expansion means, if desired. In any event, means is provided for bypassing sufficient refrigerant from the outlet of the condenser to the inlet of the compressor to assure proper functioning of the refrigeration system at all times during operation thereof.

While for purposes of illustration a preferred embodiment of the invention has been described, it will be appreciated that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A refrigeration system connected to provide refrigeration, said system comprising:

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- (1) a refrigerant compressor for compressing refrigerant vapor, said compressor having an inlet passage and a discharge passage, and said compressor being driven by an electric motor;
 - (2) a condenser for liquefying compressed refrigerant vapor, said condenser having an inlet connected to said compressor and an outlet for discharging liquefied refrigerant;
 - (3) a plurality of evaporators for vaporizing liquefied refrigerant to produce cooling at desired locations;
 - (4) a plurality of variable orifice expansion valves, one of each of the said expansion valves being associated with and disposed ahead of one of each of said evaporators for governing passage of refrigerant from the outlet of said condenser to said associated evaporator;
 - (5) a hot gas bypass passage connecting the discharge of said compressor with the inlet thereof, a hot gas bypass valve disposed in said hot gas bypass passage, said hot gas bypass valve being responsive to a function of suction pressure at the inlet of said compressor and arranged to bypass compressed hot gas discharged from said compressor to the inlet of said compressor when the suction pressure drops below a predetermined value; and
 - (6) bypass passage means for bypassing refrigerant from the outlet of said condenser to the low pressure side of the system to supply a predetermined minimum quantity of cold refrigerant to said compressor to cool said compressor motor when said hot gas bypass valve is open.
2. A refrigeration system as defined in claim 1 wherein said bypass passage comprises a fixed restriction.
 3. A refrigeration system as defined in claim 2 wherein said fixed restriction is arranged to bypass refrigerant around at least one of said thermal expansion valves into the evaporator associated with said thermal expansion valve.
 4. A refrigeration system as defined in claim 3 including a fixed restriction arranged to bypass refrigerant around each of said thermal expansion valves.
 5. A refrigeration system as defined in claim 2 wherein said fixed restriction comprises a capillary tube.

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