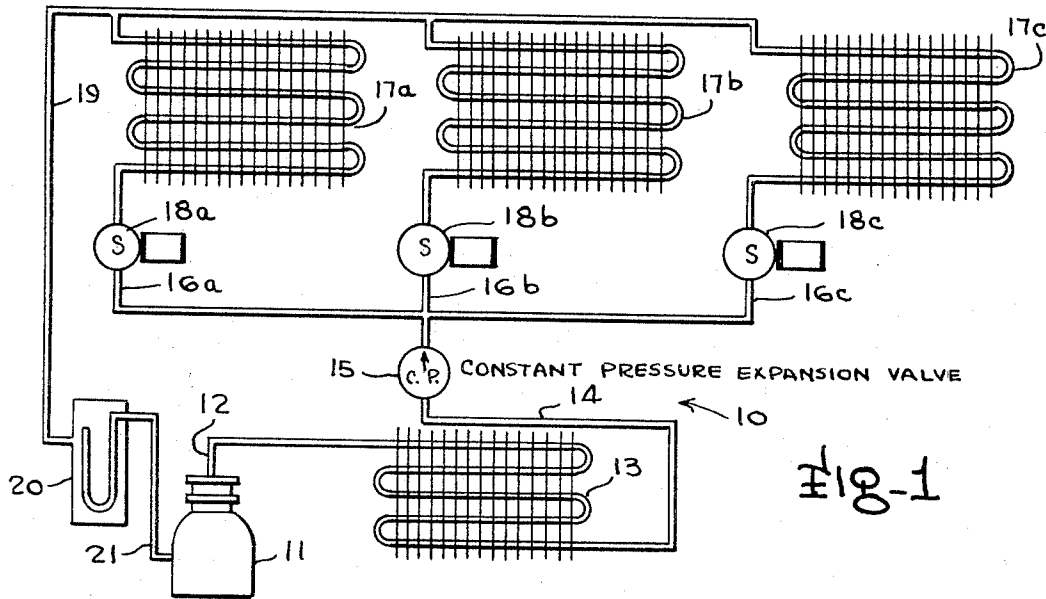
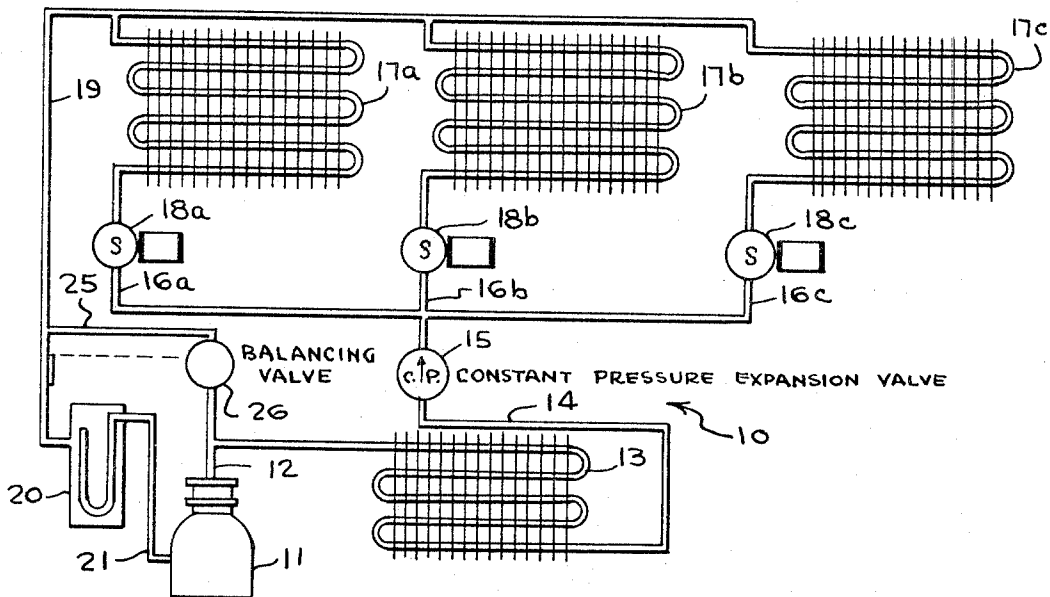


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EVAPORATOR CONTROL WITH CONSTANT PRESSURE
EXPANSION VALVE AND BY-PASS MEANS
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EVAPORATOR CONTROL WITH CONSTANT PRESSURE EXPANSION VALVE AND BY-PASS MEANS

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ABSTRACT OF THE DISCLOSURE

A refrigeration system including a compressor, a condenser, and evaporator means comprising plural separate evaporators or plural separate evaporator circuits or sections, wherein an automatic constant pressure expansion valve is provided between the condenser and the inlets to the plural evaporators or evaporator circuits to maintain a selected constant pressure at the valve outlet, locating the zone of transition of refrigerant from liquid to vapor beyond the evaporator means outlet. An accumulator is provided to trap liquid outflow from the evaporator means. A by-pass conduit regulated by a by-pass valve is connected between the compressor discharge side and the suction conduit.

The present invention relates in general to means for controlling refrigerant evaporators in refrigeration systems, air-conditioning systems, and the like, and more particularly to means for controlling refrigerant evaporators by using automatic constant pressure expansion valves.

It has been customary heretofore to control refrigerant evaporators by thermostatic expansion valves having a feeler bulb disposed to sense refrigerant temperature adjacent the exit end of an evaporator to automatically adjust the feed of refrigerant to the evaporator inlet in accordance with the temperature of the leaving refrigerant. It has been discovered that a thermostatic expansion valve required five degrees to ten degrees of superheat in order to function properly. The presence of a superheated zone in an evaporator reduces the capacity of the evaporator because heat transfer in the super-heated zone is only about one-tenth of that in the evaporating liquid zone. Thus the necessity of maintaining a superheated zone in an evaporator controlled by a thermostatic expansion valve to secure proper functioning of the thermostatic expansion valve means that that portion of the evaporator surface goes to waste. This is aggravated with multiple circuit evaporators in which feeding of the various circuits is unequal and the expansion valve is controlled by the worst circuit.

Previous investigations have indicated considerably better heat transfer from the refrigerant to the evaporator tube in so-called "flooded" evaporators. This simply means that flooded evaporators which do not have a superheated zone and which normally have no distribution problems because of the absence of an expansion valve perform better because the entire evaporator surface is fully utilized.

A thermostatic expansion valve readjusts itself continually so that its feeding rate is never constant. As a result, the location of the transition point from evaporating liquid to vapor varies over a wide range. This condition is commonly termed "hunting" of a thermostatic expansion valve. Even with a constant rate of feeding, the location of the liquid-vapor transition point appears to change in a random fashion. For this reason, I have concluded that the most advantageous location for the liquid-vapor transition point is beyond the evaporator exit so that the entire evaporator surface will be

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utilized for evaporating heat transfer, and not for superheat.

Multiple circuit evaporators are particularly difficult to control with a conventional thermostatic expansion valve system. This would be clearly understood by considering an assumed system where a ten ton air conditioning evaporator may have ten separate circuits, and be fed by a single thermostatic expansion valve. A load reduction on one of the ten circuits would cause this circuit to deliver unevaporated refrigerant to the evaporator coil outlet where it would chill the feeler bulb of the expansion valve, causing the valve to close. This would cause the remaining nine circuits to be starved, further reducing the efficiency of the evaporator, even below the reduced efficiency resulting from the necessary maintenance of the superheated zones in the evaporators.

Additionally, cold weather operation with a thermostatic valve introduces problems which have been widely recognized, resulting from the substantial variations in head pressure which arise as a result of the widely varying ambient temperature conditions when aircooled condensers are used. U.S. Patents Nos. 2,934,911, 3,139,735, 3,149,475, and 2,963,877 are typical of many patents which have proposed the incorporation of head pressure control systems in refrigeration systems using a thermostatic expansion valve. These patentees were motivated by the fact that with a thermostatic expansion valve, outlet pressure drops sharply if its inlet pressure, which is roughly the same as condensing pressure, is reduced.

I can avoid the necessity of providing any such head pressure control, however, and at the same time avoid the reduction in evaporator capacity which arises from maintaining the superheated zone necessary to insure proper functioning of thermostatic expansion valve, by employing a properly sized constant pressure expansion valve for maintaining a constant outlet pressure regardless of any drop in inlet pressure and selected to maintain the liquid-vapor transition point beyond the evaporator exit so that the entire evaporator surface is utilized for evaporating heat transfer. Additionally, such automatic constant pressure expansion valves are somewhat less costly than thermostatic expansion valves and reliably maintain a constant evaporator pressure regardless of loading. Such constant pressure expansion valves will perform better with multiple circuit evaporators providing an adequate distributor is used and the constant pressure expansion valve capacity is sufficient to feed all circuits at maximum load.

An object of the present invention, therefore, is the provision of a novel control for feeding refrigerant to an evaporator or plural evaporators which obviates the foregoing disadvantages attributable to thermostatic expansion valves, by using an automatic constant pressure expansion valve to regulate the feed of refrigerant to the evaporator or evaporators.

It will be appreciated that, at reduced loads, some unevaporated refrigerant will leave the evaporator if a constant pressure expansion valve is used to maintain constant evaporator pressure. Accordingly, another object of the present invention in the provision of a novel refrigeration system employing a constant pressure expansion valve for regulating feeding of refrigerant to the evaporator or evaporators, wherein means are provided to trap refrigerant liquid which overflows from the evaporator during periods of low load and process the same so that it is fed back to the compressor in a state which minimizes danger to the compressor.

Yet another object of the present invention is the provision of novel means in association with automatic constant pressure expansion valve control of an evaporator or evaporators to provide additional capacity control for

the evaporator or evaporators when serving widely fluctuating loads.

Other objects, advantages, and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating two preferred embodiments of the invention.

In the drawings:

FIGURE 1 is a schematic diagram of a refrigeration system embodying the present invention; and

FIGURE 2 is a schematic diagram of a modification of the refrigeration system of FIGURE 1, having an additional capacity control system associated therewith.

Referring to the drawings, wherein like reference characters designate corresponding parts throughout both figures, there is illustrated a refrigeration system, indicated generally by the reference character 10 in FIGURE 1, comprising a compressor 11 having a discharge conduit 12 connected to the discharge side or high pressure side of the compressor, which is connected to the inlet of a condenser 13, the exit or outlet of which has a liquid line 14 connected thereto. The liquid line 14 supplies the condensed liquid refrigerant from the condenser 13 to the inlet of a constant pressure expansion valve 15 of the automatic type designed to maintain a constant outlet pressure regardless of any drop in the inlet pressure to the expansion valve 15. Such constant pressure expansion valves are well known and available commercially, although designed for specifically different purposes from that of this disclosure.

The outlet of the constant pressure expansion valve 15 is connected to an inlet conduit feeding an evaporator, or in the embodiment herein specifically illustrated, a plurality of inlet conduits 16a, 16b and 16c for feeding the refrigerant to the inlet end of evaporators 17a, 17b and 17c. It will be understood that with plural evaporators, a distributor (not shown) will be provided to distribute the refrigerant to the plurality of evaporators. Suitable conventional liquid solenoid valves 18a, 18b and 18c are provided respectively in the inlet conduits 16a, 16b and 16c to permit closing of the liquid inlet line to any of the evaporators as desired. The exit ends of the evaporators 17a, 17b and 17c are connected by a common return conduit 19 to a conventional accumulator or trap 20 of well known construction, having an internal tube opening above the normal liquid level in the accumulator and communicating with the suction line 21 leading to the suction or low pressure side of the compressor 11.

The automatic constant pressure expansion valve 15 is appropriately sized for the evaporators of the system to locate the liquid-vapor transition point beyond the exit of the evaporators so that the entire surfaces of the evaporators are utilized for evaporating heat transfer, and the valve 15 is chosen to have an appropriate capacity sufficient to feed all of the evaporator circuits at maximum load. The unevaporated refrigerant which leaves the evaporator at reduced loads is collected in the accumulator 20, which is preferably located in the condenser air stream entering the condensing unit, where the unevaporated refrigerant is trapped and fed back to the compressor 11 in a "homogenized" state rather than in the form of intermittent slugs so that danger to the compressor is minimized.

If a system of this type is serving widely fluctuating loads, additional capacity control means may be provided, as indicated in FIGURE 2, which duplicates the system of FIGURE 1 but provides a hot gas by-passing line 25 controlled by a hot gas balancing valve 26 extending between the compressor discharge conduit 12 and the return conduit 19 or suction line 21, preferably joining the return line 19 upstream of the accumulator 20. The hot gas balancing valve 26 may be of the thermostatic type, having a feeler bulb attached to the suction line 21 between the accumulator 20 and the compressor 11. This

by-passing line 25 by-passes small amounts of hot discharge gas from the compressor discharge 12 into the return line 19 so that the hot gas is capable of mixing with the liquid in the accumulator 20 and thus evaporates the liquid in the accumulator during periods of reduced load. When the suction line 21 is relatively cool, the hot gas by-pass valve 26 opens and feeds hot gas toward the accumulator 20. In the event the suction line 21 is warm, indicating that only vapor is reaching the compressor 11, the hot gas by-pass valve 26 would close. This would also be the case at full load, when all refrigerant reaching the compressor suction inlet is evaporated. Valves of the type appropriate for the hot gas balancing valve 26 are commercially available, although intended for different purposes, the valve designated model 521 thermostatic by-pass valve manufactured by A-P Controls Corporation being an example of the valve that would be appropriate for this purpose.

The arrangement of FIGURE 2 with the hot gas by-pass line 25 and by-pass valve 26 has the additional advantage of providing compressor protection from floodback. In the event there is heavy floodback, particularly upon startup, the feeler element of the by-pass valve will sense a cold suction line and supply hot gas to the accumulator 20 so as to alleviate the floodback condition promptly.

The system also has the added advantage that all the necessary devices can be built into the condensing unit and do not require a separate hot gas line as, for instance, is required in systems being presently commercially promoted involving the use of regulated hot gas by-passing in conjunction with a thermostatic expansion valve to supplement the thermostatic expansion valve.

What is claimed is:

1. A refrigeration system including a compressor having discharge and suction sides, a condenser having its inlet coupled to the compressor discharge side for condensing refrigerant delivered thereto from said compressor, evaporator means having an inlet coupled through a liquid conduit to the exit of said condenser to receive liquid refrigerant from the latter, and a suction conduit connecting the exit of the evaporator means to the compressor suction side for return of refrigerant to the latter, the improvement comprising an automatic constant pressure expansion valve in said liquid conduit maintaining constant pressure at the outlet of said valve regardless of inlet pressure variations for controlling evaporator pressure conditioned to locate the zone of transition of refrigerant from liquid to vapor in said suction conduit beyond the evaporator exit, and accumulator means in said suction conduit to trap unevaporated refrigerant in said suction conduit and minimize return of liquid refrigerant slugs to said compressor, said evaporator means comprising a plurality of evaporators coupled in parallel refrigerant flow circuits between said liquid conduit and said suction line, said automatic constant pressure expansion valve being a single valve in a portion of said liquid conduit common to all said flow circuits having a capacity to feed all said circuits at maximum evaporator load, said system including a by-pass conduit regulated by a by-pass valve and connected between said compressor discharge side and said suction conduit, said by-pass valve being responsive to thermal conditions in said suction conduit to by-pass selected amounts of hot gaseous refrigerant from the compressor discharge to the suction conduit to vary evaporator capacity in selected relation to fluctuations in evaporator load.

2. A refrigeration system as defined in claim 1, wherein said by-pass conduit joins said suction conduit between said accumulator and said evaporator means whereby hot gaseous refrigerant by-passed to said suction conduit mixes with liquid refrigerant in said accumulator.

3. A refrigeration system including a compressor having discharge and suction sides, a condenser having its

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inlet coupled to the compressor discharge side for condensing refrigerant delivered thereto from said compressor, evaporator means having an inlet coupled through a liquid conduit to the exit of said condenser to receive liquid refrigerant from the latter, and a suction conduit connecting the exit of the evaporator means to the compressor suction side for return of refrigerant to the latter, the improvement comprising an automatic constant pressure expansion valve in said liquid conduit maintaining constant pressure at the outlet of said valve regardless of inlet pressure variations for controlling evaporator pressure conditioned to locate the zone of transition of refrigerant from liquid to vapor in said suction conduit beyond the evaporator exit, and accumulator means in said suction conduit to trap unevaporated refrigerant in said suction conduit and minimize return of liquid refrigerant slugs to said compressor, said system, including a by-pass conduit regulated by a by-pass valve and connected between said compressor discharge side and said suction conduit, said by-pass valve being responsive to

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thermal conditions in said suction conduit to by-pass selected amounts of hot gaseous refrigerant from the compressor discharge to the suction conduit to vary evaporator capacity in selected relation to fluctuations in evaporator load.

4. A refrigeration system as defined in claim 3 wherein said by-pass conduit joins said suction conduit between said accumulator and said evaporator means whereby hot gaseous refrigerant by-passed to said suction conduit mixes with liquid refrigerant in said accumulator.

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