This invention relates generally to improvements in a refrigeration control, and more particularly to an improved control device adapted to limit the load on the compressor motor of a refrigeration or cooling system and adapted to cool the refrigerant vapor returning to the compressor.

When the ambient temperature surrounding the condenser and evaporator increases in a cooling system of the compressor-condenser-evaporator type, the power consumption of the compressor motor increases because of an increase both of evaporator pressure and of condenser pressure. It is an important objective of the present invention to provide a control device that regulates and limits the power consumption of the compressor motor.

An important object is achieved by the provision of a control device that causes the electrical input to the compressor motor to be held to a predetermined maximum value even under conditions of high heat load.

In many refrigeration systems of this type, a thermostatic expansion valve is utilized to regulate the flow of refrigerant to the evaporator, the thermostatic expansion valve being actuated by a thermal sensing bulb located in thermostatically responsive relation to the suction line at the evaporator outlet. An important object is to provide a control device that is actuated in response to an increase in head pressure in the system to cause the thermostatic expansion valve to limit flow of refrigerant to the evaporator by affecting the temperature of the thermostatic expansion valve sensing bulb.

When the refrigerant flow to the evaporator is limited in such systems, the superheat and temperature of the refrigerant vapor entering the compressor are increased. In some cases, this condition may be harmful to the compressor motor if it is inside the compressor housing and depends on the temperature of the returning vapor to cool the motor windings.

Another important objective is achieved by the provision of a control device in the system which solves the above discussed potential heat problems by cooling the vapor at the compressor inlet with the addition of expanding refrigerant into the suction line when the vapor temperature at the evaporator outlet is increased above a safe value.

It will be realized that when the vapor temperature at the evaporator outlet is increased there is a corresponding increase in evaporator pressure and a generally proportionate increase in condenser head pressure. An important object is to provide a control device that performs the previously explained operation and function in response to an increase in head pressure above a predetermined value.

Still another important object is realized by a control device in a refrigeration system utilizing a thermostatic expansion valve, which introduces sufficient expanding refrigerant to the suction line ahead of the thermal sensing bulb only to cause the thermostatic expansion valve to limit refrigerant flow to the evaporator upon an increase of head pressure above a predetermined value.

Other important advantages are afforded in this type of system in that the flow of expanding refrigerant to the suction line can be increased by the control device so as to cool the vapor in the suction line leading to the compressor, in addition to causing a throttling action of the thermostatic expansion valve as discussed.

In other conventional refrigeration systems, a capillary tubing with an auxiliary control ahead of the capillary tubing is utilized to feed expanded refrigerant to the evaporator in lieu of a thermostatic expansion valve. In one instance, this auxiliary control is a solenoid valve operated by a pressure switch. At a predetermined head pressure, the switch closes the valve and stops refrigerant flow through the capillary tubing. An important object is achieved by the control device in this type of system in that it cools the return vapor to the compressor upon an increase of head pressure above a predetermined value so that the compressor motor temperature, even though such control device does not have any effect on the amount of refrigerant flow to and through the evaporator.

Yet another important object is achieved by the novel structure of the valve mechanism in the control device and by the provision of the control device as an article of manufacture.

Another important objective is to provide a control device in a refrigeration system that is simple and durable in construction, efficient in operation, economical to manufacture and assemble, fully automatic in operation, and which can be quickly and easily installed.

The foregoing and numerous other objects and advantages of the invention will more clearly appear from the following detailed description of a control device installed in different systems of compressor-condenser-evaporator type, and from the description of different valve structures in the control device, particularly when considered in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a refrigeration system utilizing a thermostatic expansion valve, illustrating the installation of the present control device;

FIG. 2 is a cross-sectional view of an embodiment of a valve used in the control device as seen in a vertical plane;

FIG. 3 is a cross-sectional view of another embodiment of the valve utilized in the control device;

FIG. 4 is a cross-sectional view of still another embodiment of the valve utilized in the control device, and

FIG. 5 is a diagrammatic view of a refrigeration system of compressor-condenser-evaporator type utilizing a capillary tube with an auxiliary control connected ahead of the capillary tube instead of a thermostatic expansion valve as illustrated in FIG. 1, disclosing the connection of the present control device.

Referring now by characters of reference to the drawings, and first to FIG. 1, it is seen that the control device is utilized in a refrigeration system of compressor-condenser-evaporator type. More particularly, the refrigeration system includes a compressor 10 driven by an electric motor 11, the compressor 10 being operatively connected by a line to a condenser 12. A receiver 13 is connected to the outlet of condenser 12 and is connected by a liquid line 14 to the inlet of a thermostatic expansion valve 15. The outlet of thermostatic expansion valve 15 is operatively connected by a line to the inlet of evaporator 16. The outlet of evaporator 16 is connected by a suction line 17 back to the compressor 10.

The thermostatic expansion valve 15 is of conventional construction and is a unit of this type sold by Sporlan Valve Company of St. Louis, Missouri. This expansion valve 15 has been fully and adequately described in many prior patents owned by this company including U.S. Patent No. 2,922,292, issued January 26, 1960, and entitled Valve Assembly for a Refrigeration System.

As usual, the thermostatic expansion valve 15 includes a thermal sensing bulb 20 located in adjacent
A limited fluid charge is introduced into bulb 20, and consists preferably of a fluid having characteristics approaching or identical with those of the refrigerant employed in the system, and will usually consist of Refrigerant 12, Refrigerant 22, methyl chloride or any other of the refrigerants selected for the system according to preference and field of usage. Below a predetermined temperature of bulb 20, the charge is partly in liquid phase and partly in vapor phase, while above this temperature all of this charge is in vapor phase.

The motor unit 22 of the thermostatic expansion valve 15 operates under the influence of fluid pressure changes occurring by reason of thermal effects imparted to bulb 20 in response to changes in superheat in the suction line 17. Upon a decrease in superheat, the bulb 20 will cause the motor unit 22 to throttle or limit refrigerant flow through the thermostatic expansion valve 15, and hence limits the refrigerant flow to the evaporator 16.

A control unit 23 is placed in this system as disclosed in FIG. 1 in order to limit the load on the compressor motor 11 and to cool the refrigerant vapor returning to the compressor 10. The control device includes a valve 24 that may be of the construction illustrated in FIG. 4. Inclusive, the structure of such valve being described in detail subsequently. A line 25 connects the inlet of valve 24 to the liquid line 14, while a capillary tubing 26 connects the outlet of valve 24 to the suction line 17.

For reasons which will later appear, the capillary tubing 26 is connected to and communicates with the suction line 17 at the outlet of evaporator 16 ahead of the thermal sensing bulb 20.

The valve 24 of FIG. 2 includes a body 27 having a top open chamber 30 formed therein. The body 27 is provided with a valve inlet 31 and a valve outlet 32, both communicating with chamber 30. A fitting 28 is connected to the valve inlet 31 and is adapted to be connected to the thermostatic line 25 (FIG. 1) operatively communicating with the liquid line 14. The valve outlet 32 is adapted to be connected to the capillary tubing 26.

A nipple 33 is threaded directly to the valve body 27 and is provided with a valve port 34 that communicates with the chamber 30 and with the valve outlet 32.

A valve member 35 is reciprocably mounted in valve chamber 30. The valve member includes a sleeve 36 that slidably receives nipple 33, and interfits the nipple 33. The sleeve 36 includes a plurality of lateral apertures 37 that place the chamber 30 in communication with the valve port 34. A pointed tip 38 is attached to valve member 35 and is adapted to open and close the valve port 34 upon reciprocation of valve member 35.

A compression spring 40 is located in chamber 30, one end of spring 40 engaging a collar on valve member 35 and the other end engaging the body 27 at the bottom of chamber 30. The spring 40 tends to urge the valve member upwardly into a valve open position.

The motor unit referred to at 41 is threaded directly by a casing 42 to the top of valve body 27. A diaphragm 43 constituting a flexible motor element is attached to and extends across the casing 42, dividing the casing 42 into separate compartments 44 and 45. Attached to the bottom side of diaphragm 43 is a plate 46 that engages the valve member 35.

The top of casing 42 is provided with a fitting 47 through which a charge such as air is introduced into compartment 44 at one side of diaphragm 43. This air charge is a predetermined constant pressure and is maintained by sealing off the end of the fitting tube 48. If desired, a spring may be used in lieu of an air charge or a spring may be used in combination with the air charge to provide the constant pressure.
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The interior of bellows 76 is subjected to a predetermined constant pressure such as that provided by an air charge introduced through tube 84 and fitting passage 82. The constant pressure is maintained in bellows 78 by sealing off introduction tube 84. In this embodiment, the spring 53 and the air charge tends to urge the valve member 77 in a direction to close valve port 75.

The exterior of bellows 78 is subjected to head pressure because the chamber 71 is in direct communication through valve inlet 72 to the liquid line 14. The spring 77 and the head pressure tends to urge the valve member 76 in a direction to open valve port 75.

In each of the valve embodiments illustrated in FIGS. 2-4 inclusive, the flexible motor elements such as diaphragm 43 in FIG. 2, diaphragm 64 in FIG. 3, and bellows 78 in FIG. 4 have on one side either a spring or air pressure or both constituting a predetermined constant pressure. Opposing this constant pressure is the head or liquid line pressure of the refrigeration system acting on the other side of the flexible motor elements. When the head pressure exceeds an amount as determined by the air charge pressure or by spring pressure if utilized, or by the combination of both pressures if both are utilized, the valve tends to open; and upon a sufficient head pressure increase, the valve opens completely, thus allowing refrigerant to flow from the liquid line 14 directly to the suction line 14, by-passing the evaporator.

In the refrigeration system illustrated in FIG. 1 in which a thermostatic expansion valve 15 is utilized, the refrigerant flow through the valve 24 is fed into the suction line 17 by capillary tubing 26 upstream from the bulb 20 of the expansion valve 15. The expanding refrigerant will cool the bulb 20 and hence cause the expansion valve 15 to close partly or completely. At the same time that the refrigerant flow through the evaporator 16 is reduced by the throttling action of the thermostatic expansion valve 15, refrigerant flow from the capillary tubing 26 causes a cooling of the now highly superheated vapor returning from the evaporator 16 to the compressor 10. By properly sizing the capillary tubing 26, or the valve port in the valve 24, or both, the flow of expanding refrigerant past the expansion valve bulb 20 can be regulated either to just cool the bulb 20 or to cool both the bulb and the suction vapor to any degree desired.

When below a preset value, then the air charge pressure (or the spring pressure, or both) on one side of the flexible motor element 43 in FIG. 2, 64 in FIG. 3, and 78 in FIG. 4, exceeds the head pressure and throttles or closes the valve 24, thus minimizing or eliminating the cooling effects and the system operates in a normal manner.

In some refrigeration systems, a capillary tube 90 with an auxiliary control such as solenoid valve 91 connected ahead of capillary tube 90 is utilized in lieu of a thermostatic expansion valve as illustrated in the system disclosed in FIG. 5. The solenoid valve 91 is operated by a pressure switch 92. The lines 93 are connected to an electric power supply. The other component parts of this system, FIG. 5, are the same as that disclosed previously in the system of FIG. 1.

Of course, the control device 23 shown in FIG. 1, together with the different valve embodiments of FIGS. 2-4 inclusive, can be used in the system shown in FIG. 5.

In this system, when the head pressure increases to a predetermined amount, the pressure switch 92 closes the solenoid valve 91 and shuts off the flow of refrigerant to the bulb 20. If the head pressure at the same pressure then, it is necessary for the subject control device 23 to begin to admit refrigerant vapor to cool the suction vapor. More particularly, upon an increase of head pressure above a predetermined value, the valve 24 of the control device 23 will open to permit a direct flow of refrigerant from liquid line 14 to the suction line 17, by-passing evaporator 16.

The capillary tubing 26 introduces expanding refrigerant to the suction line 17 at the outlet of evaporator 16, thus cooling the vapor returning to the compressor. Of course, in this environment, the control device 23 will have no effect on the flow of refrigerant to and through the evaporator, but the cooled vapor returning to the compressor assures that the motor windings of the compressor motor will not be harmed by excessive heat.

When the head pressure is below the predetermined value, the valve 24 in the control device closes to stop any by-passing flow of expanding refrigerant to the suction line, and the system operates in a normal manner.

Although the invention has been described by making detailed reference to a control device in different refrigeration systems and to various valve structures utilized in such device, such detail is to be understood as illustrative, rather than in any restrictive sense, many variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. In a refrigeration system, a compressor, a condenser connected to said compressor, a liquid line feeding from said condenser, an evaporator, means in said liquid line for delivering expanded refrigerant to said evaporator, a suction line connecting said evaporator to said compressor, a control valve having a body with a passage therethrough, the body having an inlet and an outlet, a line connecting said valve inlet to said liquid line, tubing connecting the valve outlet to said suction line, a partition across said passage between said valve inlet and outlet, the partition being provided with a valve port, a valve member for opening and closing said port, a motor unit including a flexible motor element operatively connected to said valve member, means placing a predetermined constant pressure on one side of said flexible motor element tending to move the valve member toward a closed position relative to said port, and means placing the other side of said flexible motor element in communication with the valve inlet and hence subject to the head pressure of said liquid line, the head pressure tending to move the valve member toward an open position, the flexible motor element causing the valve member to open said port upon subjection to a head pressure above a predetermined head pressure for feeding expanded refrigerant to the suction line to cool the vapor returning to the compressor.

2. In a refrigeration system, a compressor, a condenser connected to said compressor, a liquid line leading from said condenser, an evaporator, means in said liquid line for delivering expanded refrigerant to said evaporator, a suction line connecting said evaporator to said compressor, a valve including a body provided with a chamber therein, a valve inlet communicating with said chamber, a valve outlet on said chamber, means providing a valve port communicating said chamber with said valve outlet, a valve member for opening and closing said port, means mounting the valve member for reciprocating movement in said chamber toward and away from the valve port, a line connecting said valve inlet to said liquid line, tubing connecting the valve outlet to said suction line, a flexible motor element in said chamber operatively connected to said valve member, the flexible motor element having one side communicating with said chamber and subjected to the head pressure of the system, and means subjecting the other side of said flexible motor element to a constant predetermined pressure, said flexible motor element causing said valve member to open said port upon subjection to a head pressure above a predetermined head pressure for feeding expanded refrigerant to the suction line to cool the vapor returning to the compressor.

3. In a refrigeration system, a compressor, a condenser operatively connected to said compressor, a liquid line leading from said condenser, an evaporator having an inlet and an outlet, a thermostatic expansion valve connected
to said liquid line and to said evaporator inlet for delivering expanded refrigerant to said evaporator, a suction line connecting the evaporator outlet to said compressor, the thermostatic expansion valve having a thermal sensing bulb adjacent the suction line at the evaporator outlet for regulating flow through said thermostatic expansion valve, a control means including a control line interconnecting the liquid line to the suction line ahead of said thermal sensing bulb and by-passing said evaporator, a valve in said control line, and motor means connected to said valve and operatively connected to said liquid line for opening the valve above a predetermined head pressure to feed expanded refrigerant to the suction line to cool the vapor returning to the compressor and to cool the bulb so as to limit flow through the thermostatic expansion valve.

4. In a refrigeration system, a compressor, a condenser operatively connected to said compressor, a liquid line leading from said condenser, an evaporator having an inlet and an outlet, a thermostatic expansion valve connected to said liquid line and to said evaporator inlet for delivering expanded refrigerant to said evaporator, a suction line connecting the evaporator outlet to said compressor, the thermostatic expansion valve having a thermal sensing bulb located in thermo-responsive relation to the suction line at the evaporator outlet, a control valve including a body having a valve inlet and a valve outlet interconnected by a passage, a flow line connecting the valve inlet to said liquid line, tubing connecting the valve outlet to said suction line ahead of said thermal sensing bulb and by-passing said evaporator, a valve member in said body for controlling flow of refrigerant through said passage and hence from the liquid line to said suction line, a motor means connected to said valve member, means actuating the motor means to head pressure of said liquid line, the motor means actuating said valve member responsive to a head pressure above a predetermined head pressure to open said control valve for feeding expanded refrigerant to the suction line to cool the vapor returning to the compressor and to cool the bulb so as to limit flow through the thermostatic expansion valve.

5. In a refrigeration system, a compressor, a condenser operatively connected to said compressor, a liquid line leading from said condenser, an evaporator having an inlet and an outlet, a thermostatic expansion valve connected to said liquid line and to said evaporator inlet for delivering expanded refrigerant to said evaporator, a suction line connecting the evaporator outlet to said compressor, the thermostatic expansion valve having a thermal sensing bulb disposed in thermo-responsive relation to the suction line at the evaporator outlet, a control valve having a body provided with a chamber, the body being provided with a valve inlet communicating with said chamber, said body being provided with a valve outlet, means providing a valve port communicating said valve outlet with said chamber, a valve member in said chamber for opening and closing said port, means mounting said valve member for reciprocating movement toward and away from valve port, a flexible motor element in said chamber operatively connected to said valve member for reciprocating movement, a flow line connecting the valve inlet to said liquid line and subjecting the chamber and one side of said flexible motor element to the head pressure of said liquid line, the head pressure tending to move the valve member in a direction toward an open position relative to said valve port, means subjecting the other side of said flexible motor element to a predetermined constant pressure tending to move the valve member in a direction toward a closed position relative to said port, and a tubing connecting the valve outlet to the suction line ahead of said thermal sensing bulb at the evaporator outlet, the flexible motor element opening said port upon subjecting to a head pressure above a predetermined head pressure for feeding expanded refrigerant to the suction line to cool the vapor returning to the compressor and to cool the bulb so as to limit flow through the thermostatic expansion valve.

6. In a refrigeration system, a compressor, a condenser connected to said compressor, a liquid line leading from said condenser, an evaporator, means in said liquid line for delivering expanded refrigerant to said evaporator, a suction line connecting said evaporator to said compressor, a control line directly interconnecting the liquid line to said suction line and by-passing said evaporator, valve means in said control line, said valve means including a valve port, a valve member for opening and closing said port, and a motor means operatively connected to said valve member, means placing a predetermined constant pressure on said motor unit tending to move the valve member toward a closed position relative to said port, and means placing the motor means in communication with the head pressure of said liquid line in opposition to the said predetermined constant pressure, the head pressure tending to move the valve member toward an open position, the motor means causing the valve member to open said port upon subjecting to a head pressure above a predetermined head pressure for feeding expanded refrigerant to the suction line to cool the vapor returning to the compressor.

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