

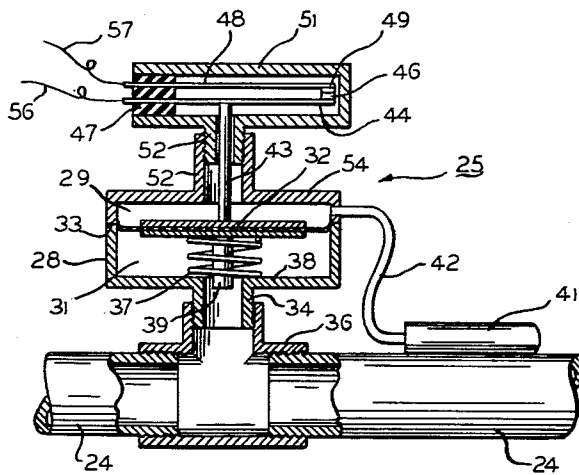
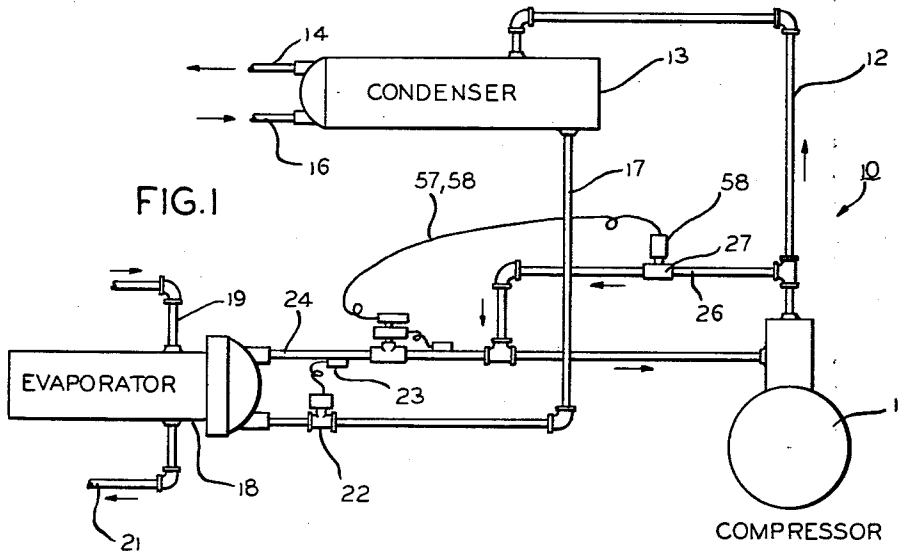
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ANTI-SLUG CONTROL FOR REFRIGERATION CIRCUITS

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ANTI-SLUG CONTROL FOR REFRIGERATION CIRCUITS

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This invention relates generally to refrigeration systems, and particularly to structure for preventing the occurrence of a slug of liquid refrigerant at the suction side of the compressor of such system.

In the conventional refrigeration system comprising a compressor, condenser and evaporator there are times when the refrigerant in the suction line connecting the evaporator with the intake to the compressor does not have the requisite superheat to insure against the possibility of a slug of liquid refrigerant reaching the compressor. This may be prevalent on start up, and may also occur during operation, and liquid refrigerant can readily cause damage to the compressor during its compression stroke.

According to the present invention the possibility of a slug of liquid refrigerant reaching the compressor is obviated by structure which senses the pressure and temperature of the suction line as a measure of the superheat. The structure controls the by-pass of a portion of the hot compressed gaseous refrigerant from the compressor into the suction line to raise the superheat to a value insuring that no solid refrigerant reaches the suction side of the compressor. Such structure includes a by-pass valve connected in the aforesaid line, and connected in a control circuit including the sensing structure.

With the foregoing considerations in mind it is a principal object of the invention to provide structure for preventing the possibility of a slug of liquid refrigerant from entering the suction side of a refrigerant compressor.

Another object is to provide structure and a control therefor for the aforesaid purpose.

Other objects and important features of the invention will be apparent from a study of the specification following taken with the drawing which together describe and illustrate a preferred embodiment of the invention and what is now considered to be the best mode of practicing the principles thereof. Other embodiments may be suggested to those having the benefit of the teachings herein, and such other embodiments are intended to be reserved especially as they fall within the scope and spirit of the subjoined claims.

In the drawing:

FIG. 1 shows a refrigeration circuit having the anti-slug control according to the present invention embodied therein; and

FIG. 2 is a detailed cross sectional view showing structure for sensing the pressure and temperature of the suction line to the compressor and operable to control the by-pass of a portion of hot compressed gaseous refrigerant into the suction line to increase the superheat therein.

Referring now particularly to FIG. 1 of the drawing, there is shown a refrigerant circuit indicated generally by the reference numeral 10, and including a motor driven compressor 11 having a discharge line 12 connected to a condenser 13. Coolant is circulated through the condenser 13 by means of a supply coolant conduit 14 and a return conduit 16.

The compressed and cooled refrigerant leaves the condenser 13 by means of a line 17 connected to an evaporator 18, which may be of the shell and tube type. Evaporator 18 is adapted to chill water or other liquid, evaporator 18 being connected to supply and return lines 19 and 21 respectively. The expansion of refrigerant within evaporator 18 is controlled by an expansion valve 22 con-

nected in the line 17, it being controlled by a temperature sensing element 23 in contact with a suction line 24 between the evaporator 18 and the suction side of the compressor 11.

The refrigerant returning to the compressor 11 and in the suction line 24 may not have the requisite amount of superheat therein to obviate the presence of slugs of liquid refrigerant and the presence of such slugs of liquid refrigerant at the intake or suction side of compressor 11 can cause damage thereto upon the compression stroke.

Structure is accordingly provided which will by-pass a portion of the hot compressed gaseous refrigerant into the suction line to raise the superheat of the refrigerant therein to a value insuring against the presence of such slug of liquid refrigerant.

A by-pass line 26 is accordingly connected between the output of the compressor 11 and the suction line 24, and has a solenoid operated valve 27 connected therein. The precise details of the solenoid operated valve 27 are not a part of the present invention, it being sufficient to say that the valve will meter a portion of the output from the compressor 11 into the suction line 24.

Structure is provided for sensing the pressure and the temperature of the suction line 24 as a measure of the superheat therein. Such structure is referred to generally by the reference numeral 25 and includes a housing 28 having a pair of chambers 29 and 31 separated by a diaphragm 32 held along its periphery 33 in the wall of the housing 28 in any convenient manner.

Chamber 31 has a cylindrical threaded boss 34 extending therefrom which is threaded into a T 36 connected in the line 24.

The pressure in the suction line 24 is thus manifested against the underside of the diaphragm 32, and the suction pressure within the conduit 24 is opposed by a light spring 37 constrained between the diaphragm 32 and the wall 38 of the housing 28, there being a guide rod 39 extending from diaphragm 32 for the spring 37.

The temperature in the suction line 24 is sensed by a vapor bulb 41 in contact therewith, vapor bulb 41 being connected by a capillary tube 42 to the chamber 29. A push rod 43 extending from the upper side of the diaphragm 32 is in contact with a contact arm 44 having a contact 46 at the end thereof. Contact arm 44 is held in a stack support 47 which also supports cooperating contact arm 48 having a contact 49 at the end thereof, the contact assembly just described being held within a housing 51 having a threaded boss 52 which guides the push rod 43. A threaded boss 52 is threaded into a hollow cylindrical boss 53 extending from a wall 54 of the housing 28.

Contact arms 44 and 48 are respectively connected to leads 56 and 57 connected to a solenoid actuator 58 for the solenoid operated valve 27, there being a suitable source of energy connected in circuit with the leads 56 and 57 to control the energization of the solenoid 58 in a manner well known in the art.

The expansion of the fluid within the vapor bulb 41 upon an increase of temperature in the suction line 24 causes pressure against the upper side of the diaphragm 32 tending to move the same in a downward direction to open the contacts 46 and 49 to de-energize the solenoid 58 and maintain the solenoid operated valve 27 closed. This movement of the diaphragm is, of course, opposed by the light spring 37. The movement of the diaphragm 32 is also influenced by the pressure in the suction line 24 which may be either sub-atmospheric or super-atmospheric depending upon the conditions obtaining.

Desirably, the closing of the contacts 46 and 49 is indicated when the superheat of the refrigerant within the suction line 24 is less than approximately 2° for a

given pressure and temperature condition. When the superheat falls below this more or less arbitrary value, there is the possibility of some of the refrigerant in the suction line 24 being in the liquid state. In such state, and when entering the suction side of the compressor 11 there is always the danger of damage thereto. At any time when the superheat in the suction line 24 falls below the arbitrary selected value, the solenoid operated valve 27 is caused to open so that a portion of the hot gases from the compressor 11 can be by-passed into the suction line 24 to give the refrigerant therein the necessary amount of superheat. By giving the necessary superheat to the refrigerant in the suction line 24, the possibility of a slug of liquid refrigerant reaching the suction side of the compressor is entirely eliminated.

While the invention has been described in terms of a preferred embodiment thereof, its scope is not intended to be limited by the precise embodiment herein shown nor otherwise than by the scope of the claims here appended.

I claim:

1. In a refrigeration circuit comprising a compressor for refrigerant, a condenser including a refrigerant line connected between said condenser and the discharge side of said compressor, an evaporator connected to said condenser including means disposed between said condenser and said evaporator for expanding refrigerant, a suction line connected between said evaporator and the suction side of said compressor, means for preventing the movement of slugs of liquid refrigerant to said compressor comprising a by-pass line connected between the discharge side of said compressor and said suction line, a by-pass valve connected in said by-pass line and adapted to control the by-pass of superheated refrigerant to said suction line, said by-pass line being connected to said suction line between said by-pass valve and the suction side of said compressor, the improvement in said circuit which include means for opening said by-pass valve when the superheat in said suction line is below a certain value, said means comprising a housing having a pair of chambers separated by a common diaphragm, one of said chambers containing fluid which expands and contracts in accordance with the temperature in said suction line, temperature sensing means in contact with said suction line and in communication with said one fluid containing chamber of said housing, the other of said chambers having means connecting the same to said suction line, means connected to said diaphragm and movable in response to the pressure and temperature conditions in said suction line, a circuit including means for operating said by-pass valve, and switch means connected in said circuit and operable to closed and open positions by engagement therewith by said means connected to said diaphragm and movable with same in response to pressure and temperature conditions for controlling said by-pass valve.

2. In a refrigeration circuit comprising a compressor for refrigerant, a condenser including a refrigerant line connected between said condenser and the discharge side of said compressor, an evaporator connected to said condenser including means disposed between said condenser and said evaporator for expanding refrigerant, a suction line connected between said evaporator and the suction side of said compressor, means for preventing the movement of slugs of liquid refrigerant to said compressor comprising a by-pass line connected between the discharge side of said compressor and said suction line,

a by-pass valve connected in said by-pass line and adapted to control the by-pass of superheated refrigerant to said suction line, said by-pass line being connected to said suction line between said by-pass valve and the suction side of said compressor, the improvement in said circuit which include means for opening said by-pass valve when the superheat in said suction line is below a certain value, said means comprising a housing having a pair of chambers separated by a movable wall element, one of said chambers containing fluid which expands and contracts in accordance with the temperature in said suction line, temperature sensing means in contact with said suction line and in communication with said one fluid containing chamber of said housing, the other of said chambers having means connecting the same to said suction line, means connected to said movable wall element and movable in response to the pressure and temperature conditions obtaining in said suction line, a circuit including means for operating said by-pass valve, and switch means connected in said circuit and operable to closed and open positions by engagement therewith by said means connected to said diaphragm and movable with same in response to pressure and temperature conditions for controlling said by-pass valve.

3. In a refrigeration circuit comprising a compressor for refrigerant, a condenser including a refrigerant line connected between said condenser and the discharge side of said compressor, an evaporator connected to said condenser including means disposed between said condenser and said evaporator for expanding refrigerant, a suction line connected between said evaporator and the suction side of said compressor, means for preventing the movement of slugs of liquid refrigerant to said compressor comprising a by-pass line connected between the discharge side of said compressor and said suction line, a by-pass valve connected in said by-pass line and adapted to control the by-pass of superheated refrigerant to said suction line, said by-pass line being connected to said suction line between said by-pass valve and the suction side of said compressor, the improvement in said circuit which include means for opening said by-pass valve when the superheat in said suction line is below a certain value, said means comprising a housing having a pair of chambers separated by a movable wall element, one of said chambers containing fluid which expands and contracts in accordance with the temperature in said suction line, temperature sensing means in contact with said suction line and in communication with said one fluid containing chamber of said housing, the other of said chambers having means connecting the same to said suction line, means connected to said movable wall element and movable in response to the pressure and temperature conditions in said suction line, switch means connected to said last named means and said movable wall element in accordance with the pressure and temperature conditions obtaining in said suction line, and a circuit including said switch means operable to closed and open positions by engagement therewith by said means connected to said movable wall element and movable with the same in response to pressure and temperature conditions for operating said by-pass valve.

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