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Proctor [45] **June 6, 1972**

[54] **REFRIGERATION SYSTEM WITH EVAPORATOR OUTLET CONTROL VALVE**

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[52] **U.S. Cl.** **62/217,** 62/225
[51] **Int. Cl.** **F25b 41/04**
[58] **Field of Search** 62/205, 209, 210, 211, 212, 62/224, 225, 217

[56] **References Cited**

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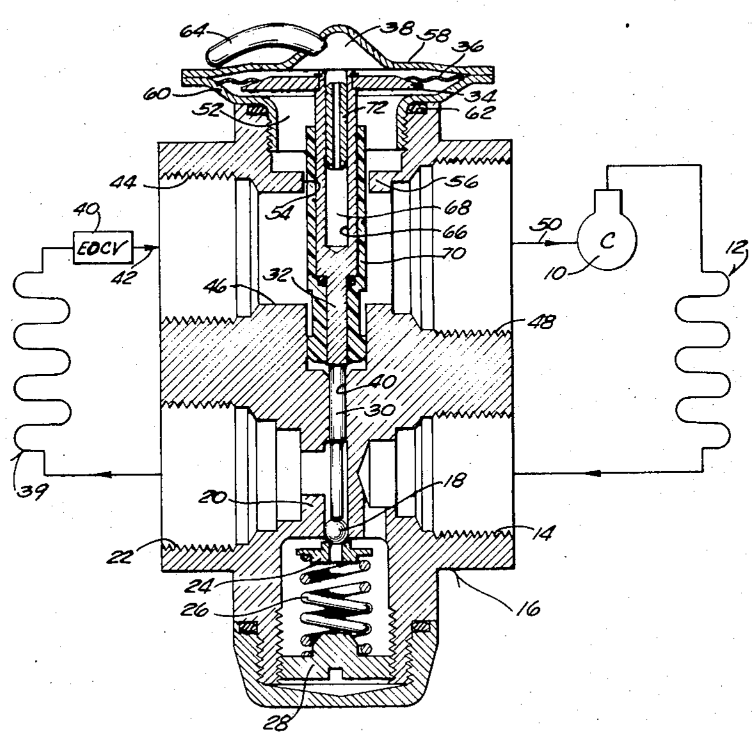
[57] **ABSTRACT**

Refrigerant flows from the compressor and condenser to the evaporator by a thermostatic expansion valve having its pressure and temperature sensing points in the suction line downstream of the evaporator outlet control valve which regulates the evaporator pressure relatively independently of the suction line conditions. When the compressor capacity significantly exceeds evaporator capacity this system provides additional compressor cooling at low suction pressures. The expansion valve may be the bulbless type or the externally equalized type. The outlet control valve may respond to refrigerant temperature at the coil outlet, or to fin temperature, or may be an evaporator pressure regulator valve.

8 Claims, 2 Drawing Figures



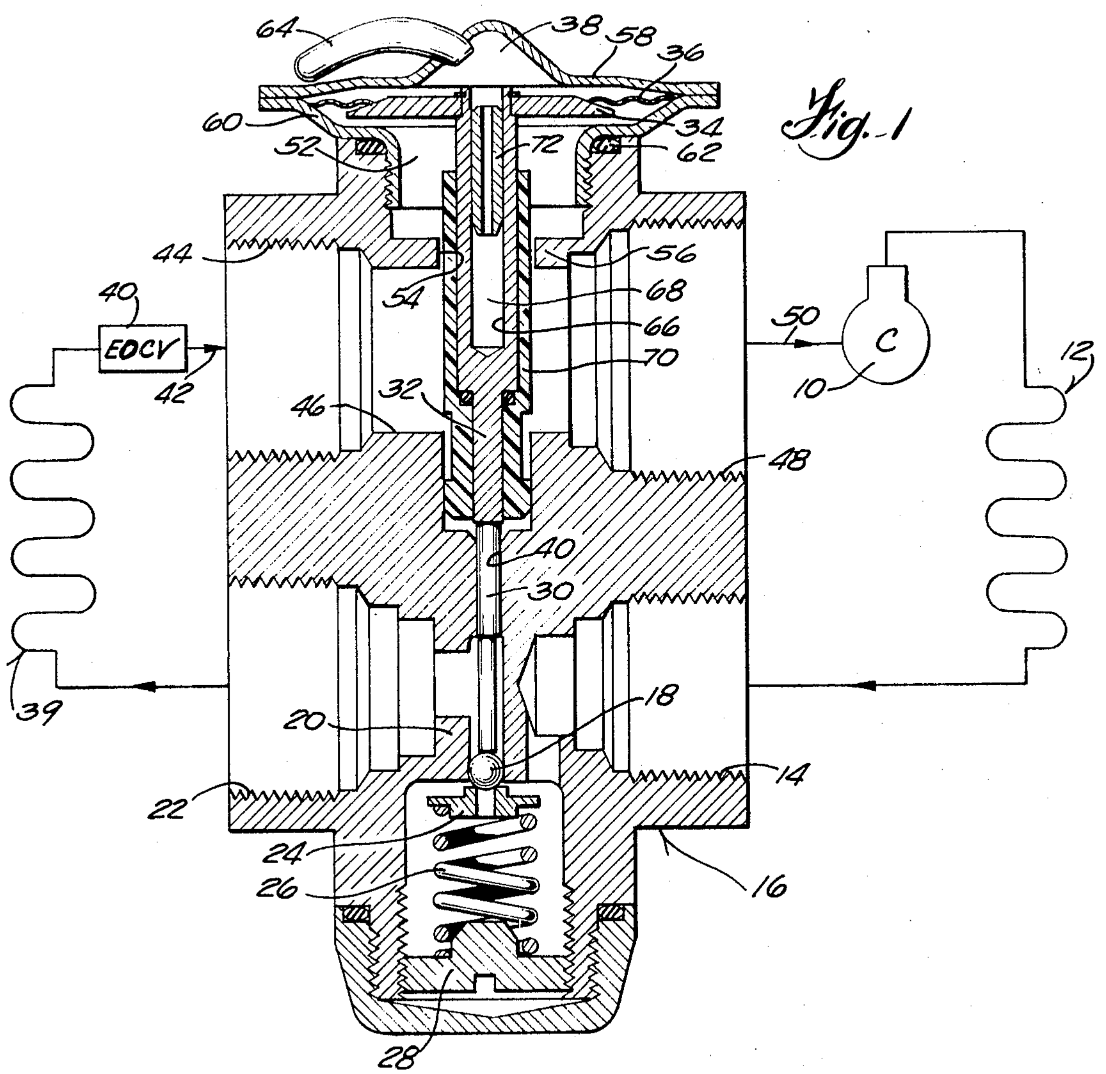


Fig. 1

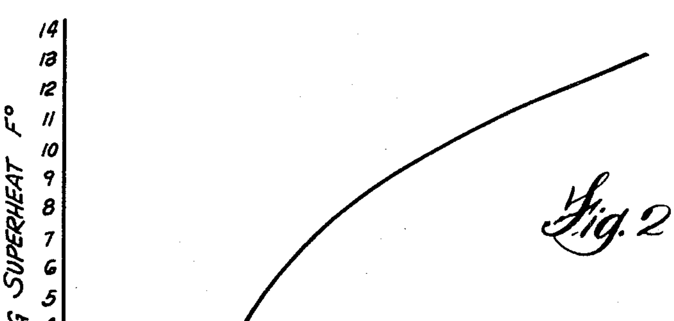


Fig. 2

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REFRIGERATION SYSTEM WITH EVAPORATOR OUTLET CONTROL VALVE

BACKGROUND OF INVENTION

In refrigeration systems having compressor capacity which may greatly exceed the evaporator capacity or load such as typical of automotive air conditioning systems, especially those required to run continuously, provision against icing the evaporator coil typically uses an evaporator outlet control valve located downstream of the temperature sensing point of the thermostatic expansion valve. This typically results in lesser refrigerant flow as the load decreases resulting in warmer refrigerant going to the compressor at lower pressures. This reduces cooling and lubrication of the compressor and may damage the compressor.

SUMMARY OF INVENTION

By controlling a cross charged thermostatic expansion valve in accordance with temperature and pressure downstream of the evaporator outlet control valve as described in the Abstract the expansion valve can be designed to approach 0° superheat at low suction pressures. This results in either liquid refrigerant or gaseous refrigerant at saturation temperature leaving the evaporator coil to provide additional (and necessary) cooling and lubrication to the compressor. The evaporator outlet control valve even functions as an expansion valve of sorts and the liquid entering the suction line creates an artificial load by cooling the suction line and expands in the compressor cylinder (reducing the compressor capacity). The ability to maintain 0° superheat at low suction pressures also results in the thermostatic expansion valve opening more and more often and thus aids the evaporator outlet control valve in maintaining the desired pressure in the evaporator coil.

The point of novelty is the use of a cross charged thermostatic expansion valve in a refrigeration system to regulate flow to the evaporator coil in accordance with temperature and pressure conditions downstream of an evaporator outlet control valve.

The usual thermostatic expansion valve is charged with the same medium as used as the refrigerant in the system. Such a valve is designated system charged. A cross charged expansion valve is charged with a medium having a temperature-pressure curve other than the temperature-pressure curve of the refrigerant. By selection of the cross charge the suction pressure corresponding to 0° superheat can be selected to suit the particular system. Since the superheat/pressure curve is "reversed" the rapid pull down benefits are realized. Under normal conditions normal operation is obtained.

DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic of a refrigeration system incorporating an evaporator outlet control valve and a bulbless thermostatic expansion valve with the latter being shown in vertical section.

FIG. 2 is a pressure-temperature curve of the thermostatic expansion valve cross charged in accordance with this invention and incorporated in the system of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

At the outset it should be noted that the bulbless thermostatic expansion valve shown in the drawings simplifies the disclosure of the means for sensing both pressure and temperature at a point downstream from the evaporator control valve. An external equalizer type of thermostatic expansion valve could be used with its feeler bulb positioned on the suction line downstream of the evaporator outlet control valve and with the equalizer connection also being in the suction line downstream of the control valve. Since externally equalized thermostatic expansion valves are well known in the art, it is not deemed necessary to illustrate this variation. As pointed out hereinafter, either type thermostatic expansion valve is cross charged in this system.

Refrigerant flows from compressor **10** to condenser **12** and from the condenser may flow either to a receiver (not shown) or directly into inlet **14** of the thermostatic expansion valve **16**. The ball type valve **18** controls the flow through the partition **20** to outlet **22**. Valve **18** rests on spring seat **24** and is biased upwardly towards its seated position by spring **26** which may be adjusted (superheat adjustment) by turning seat **28**.

The valve is actuated by push pin **30** which in turn is actuated by diaphragm rider pin **32** fixed to diaphragm pad **34** and having an end projecting through the pad and diaphragm **36** to communicate with head chamber **38**. Pin **30** has a close sliding fit in bore **41** to minimize the leakage along this portion since any such leakage would constitute a bypass. Flow from the valve outlet flows to the evaporator coil **39** and then passes through the evaporator outlet control valve **40** which may be an evaporator pressure regulator valve or may be a fin temperature sensing valve or may be responsive to refrigerant temperature at the coil outlet. Any of these evaporator outlet control valves operates in one way or another to control flow from the evaporator coil to prevent freeze-up of the coil under low load/high capacity conditions. All these valves function to control the pressure (and temperature since they are related) in the coil just above the coil freezing conditions.

Flow from the control valve **40** enters a suction line **42** to the upper return conduit of the expansion valve at inlet **44** and passes through conduit **46** over the rider pin to the outlet **48** and then to the suction line **50** leading to the compressor intake. If desired, the control valve can be designed to lead directly to the return conduit **46** of the expansion valve (that is, the line **42** can be omitted). Pressure in the return conduit in the expansion valve can communicate with chamber **52** below the diaphragm through port **54** and the upper wall **56** of the valve body. Leakage between the rider pin and wall **56** is desired. Diaphragm **36** is mounted between the domed head **58** and support cup **60** threaded into the upper end of the valve body and sealed with respect thereto by means of O-ring **62**. Head chamber **38** is cross charged with a temperature responsive charge through capillary tube **64** which is then sealed off.

As mentioned above, the cross charge terminology connotes that the charging medium has a temperature/pressure curve other than the temperature/pressure curve of the refrigerant. In this instance it is selected to approach 0° superheat for the thermostatic expansion valve as the suction line pressure (sensed in return conduit **36**) approaches 0 PSIG.

It will be noted that rider pin **32** is provided with a blind hole **66** which terminates at approximately the midpoint of the return flow path through the upper portion of the valve body. The blind hole, in effect, provides a small temperature sensing chamber **68** inside the rider pin and located in the system return path downstream of the evaporator outlet control valve **40**. Pin chamber **68** will always be colder than head chamber **38** and, therefore, the refrigerant charge will tend to condense in chamber **68** and the control point will be at this location which is ideally situated. Since there is not much mass involved in the rider pin, the response of the valve would tend to be too rapid. To damp the hunting effect a low thermoconductivity sleeve **70** of Delrin (which is self-lubricating) is mounted over the rider pin.

To make the valve mountable in all positions capillary restricter **72** is fitted in the upper end of the rider pin. This then provides a very small capillary hole connecting the rider pin chamber **68** to head chamber **38**. This is adequate for transfer of pressure changes but will minimize migration of any condensed refrigerant in chamber **68** to the head chamber should the valve be mounted upside down. Without this restricter there could be such migration with the result that the liquid refrigerant migrating to the head chamber (which is warmer) would flash to gas (increasing the pressure) and then promptly be recondensed in chamber **68**. This would induce hunting in the system. With the restricter the hunting is minimized.

FIG. 2 shows the curve of a cross charged thermostatic expansion valve opening superheat versus the suction pressure influencing the thermostatic expansion valve. It will be noted that as the suction pressure (the pressure in chamber **52**) falls, the superheat opening temperature of the expansion valve also falls. This is contrary to the performance of a system charged expansion valve which tends to increase the superheat temperature as the pressure falls. As an example of cross charging, the chambers **38** and **68** may be charged (through capillary **64**) to 31 PSIG with SO_2 with the complete valve at 75° F. The SO_2 source is then shut off close to the valve by means of a hand valve. Then the charging fixture is evacuated and the entire valve is immersed in a 32° F. bath. Argon at 32 PSIG is then applied to the charging fixture and the hand valve is opened to apply the Argon to the chambers. Then the capillary is crimped and sealed. Other proportions or refrigerants can be used.

Since this system utilizes an evaporator outlet control valve which will operate to keep the pressure (and temperature) of evaporator coil **39** to prevent icing the coil even through the compressor capacity exceeds the evaporator capacity, the compressor **10** will tend to pull down the pressure in the suction line **42–50** to very low levels. This low pressure is sensed in chamber **52** and exerts a force on the diaphragm tending to open the valve. Due to the cross charge in the diaphragm and rider pin chambers giving the operating characteristic shown in FIG. 2 the valve **18** opens at a desired low suction pressure rather than having less tendency to open. In FIG. 2 it is shown that with a suction pressure about 11-½ pounds the valve will open at 0° superheat which means that at the point the expansion valve will start passing liquid to the evaporator coil and the evaporator outlet control valve will open and pass liquid or gaseous refrigerant (at saturation temperature) to the suction line. Thus the refrigerant in the suction line is at a lower temperature (than in other systems) which facilitates cooling the compressor and liquid refrigerant will actually reach the compressor and expand in the compressor adding further cooling. Furthermore, the entire suction line from the control valve **40** to the compressor has now been made, in effect, an additional coil and introduces an artificial additional load on the system. The net effect of the cooler refrigerant and liquid refrigerant reaching the compressor coupled with the artificial load of the suction line is to virtually eliminate the possibility of damage to the compressor. The curve of FIG. 2 also shows that the thermostatic expansion valve will pass liquid well before the compressor can reduce the suction line pressure to **0** PSIG. Experience shows no harm to the compressor receiving substantial liquid even enough to show liquid in the line going to the condenser.

FIG. 2 points up a further advantage in this system in that the superheat setting of the cross charged thermostatic expansion valve increases as higher pressures exist in the suction line. This is contrary to a system charged valve. Therefore, on initial start-up with a high pressure in the suction line the valve operates at increased superheat and, therefore, facilitates rapid pull down of the pressure which means more rapid cooling.

This system, therefore, functions to protect the compressor and also gives better performance during pull down. Benefits are realized both under the low load/high capacity condition and under the high load condition of pull down. In normal load situations the superheat of the valve is normal and operation is normal.

I claim:

1. A refrigeration system comprising,
a compressor,
a condenser receiving compressed refrigerant from the compressor,
an evaporator coil,
a thermostatic expansion valve regulating flow from the condenser to the evaporator coil,
a suction line connecting the coil to the compressor inlet,
an evaporator outlet control valve in the suction line and operative in response to a control condition to regulate flow from the coil to prevent freeze-up of the coil,
said thermostatic expansion valve being responsive to both temperature and pressure in the suction line downstream of the evaporator outlet control valve and being cross charged to reduce the coil outlet superheat as the suction line pressure is reduced.

2. A refrigeration system according to claim 1
in which the thermostatic expansion valve has a valve regulating flow to the coil and actuated by a diaphragm one side of which is subjected to pressure in a chamber cross changed with a medium responsive to temperature in the suction line downstream of the evaporator outlet control valve and the other side of the diaphragm being subjected to pressure in a chamber which pressure is a function of the suction line pressure downstream of the evaporator outlet control valve.

3. A refrigeration system according to claim 2 in which the evaporator outlet control valve is responsive to temperature or pressure to throttle flow from the coil to maintain minimum temperature and pressure conditions in the coil preventing freeze-up.

4. A refrigeration system according to claim 3 in which the evaporator outlet control valve responds to evaporator pressure.

5. A refrigeration system according to claim 3 in which the evaporator outlet control valve responds to the temperature of the coil fins.

6. A refrigeration system according to claim 3 in which the evaporator outlet control valve responds to refrigerant temperature in the coil.

7. The refrigeration system according to claim 2 in which the refrigerant flow from the evaporator outlet control valve passes directly over the temperature sensing point of the thermostatic expansion valve.

8. The refrigeration system according to claim 7 in which the thermostatic expansion valve includes a valve actuating pin connecting the diaphragm to the valve and the pin is hollowed out and communicates with the chamber on said one side of the diaphragm,
a return conduit through the thermostatic expansion valve and forming part of the suction line, the hollowed portion of the pin being located in the return conduit whereby the temperature is sensed at the pin and the pressure in the return conduit communicates with the chamber on said other side of the diaphragm.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,667,247 Dated June 6, 1972

Inventor(s) Robert H. Proctor

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 30, "the" (first occurrence) should read -- that --.

Column 4, line 25, "changed" should read -- charged --.

Signed and sealed this 12th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents