

Patented May 8, 1973

3,731,498

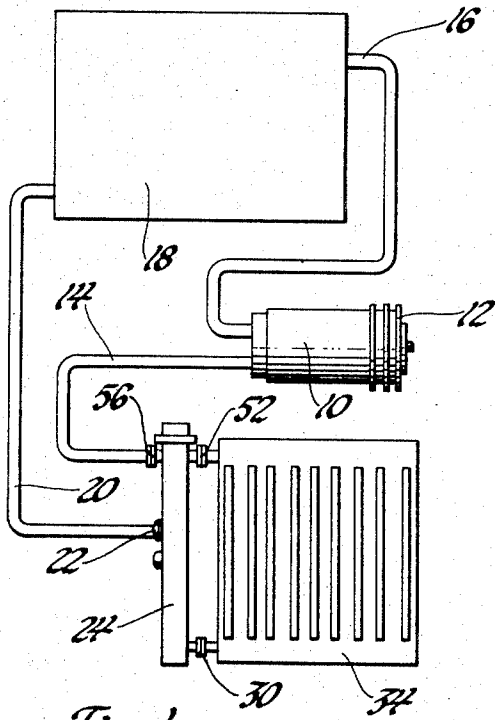


Fig. 1

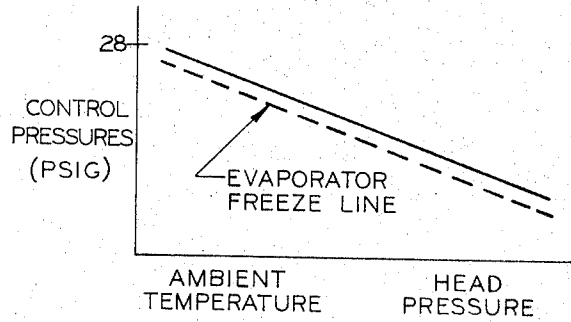


Fig. 3

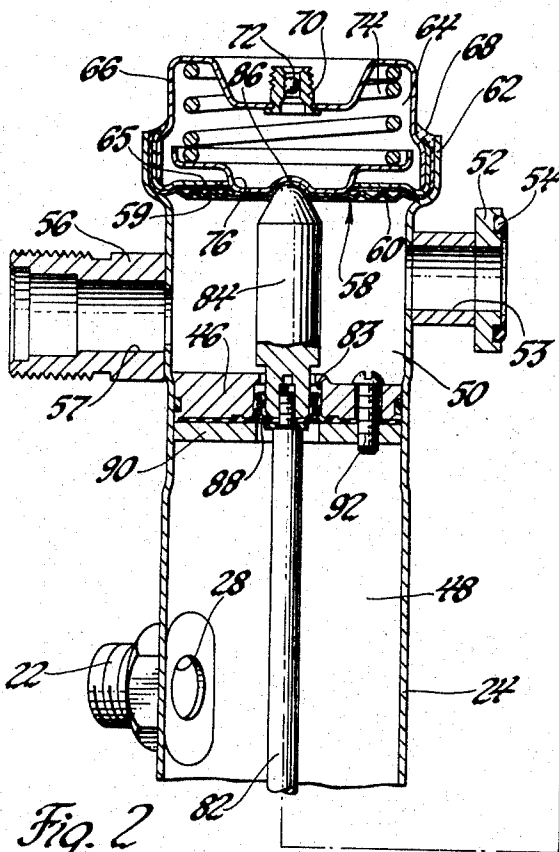
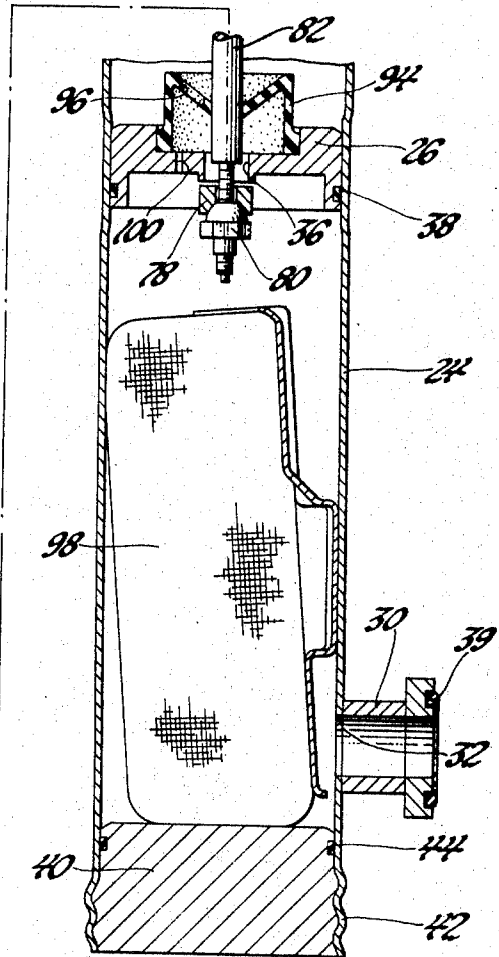


Fig. 2



INVENTORS
Paul K. Beardenbough,
 BY *Gary E. Nichols &*
Carl A. Scherer
K. H. MacLean, Jr.
 ATTORNEY

AUTOMATIC EXPANSION VALVE, PAD MOUNTED, NON-PILOTED

This invention relates to refrigerant apparatus for automobile air conditioning systems and specifically to a pressure responsive expansion valve.

When refrigerant compressors are driven directly by automobile engines as in most auto air conditioners, there is a tendency for the evaporator to frost or freeze up under conditions of relatively cool ambient temperatures and high engine and compressor speeds. Low evaporator temperatures causing frost accumulation correspond to low refrigerant pressure within the evaporator because the boiling point of refrigerants decreases with decreasing pressures. It is common to provide a flow restricting valve in series with the compressor suction or inlet line to maintain refrigerant pressure in the evaporator above a predetermined low pressure corresponding to an evaporator temperature of 32° F or slightly above. The subject pressure responsive expansion valve eliminates the need for a flow restricting valve in the suction line by controlling the quantity of refrigerant introduced to the evaporator in response to evaporator pressure.

The present expansion valve includes a control portion fluidly connected to the evaporator outlet and a metering portion fluidly connected to the evaporator inlet and separated by a wall member. A valve passage and valve element within the metering portion control the refrigerant flow into the evaporator. The valve element is operably connected to a diaphragm within the control portion by a valve rod extending through the wall member which responds to refrigerant pressure in the evaporator outlet to move the valve element towards a closed position with increasing refrigerant pressure in the control portion. The diaphragm moves the valve element towards a more open position with decreasing refrigerant pressure. Unlike thermally responsive expansion valves which open and close to maintain a predetermined superheat temperature in the evaporator outlet, the present refrigerant pressure responsive expansion valve does not maintain superheat temperatures at the evaporator outlet. Superheat is the temperature increase of the refrigerant above its boiling point at a given pressure. The present pressure responsive expansion valve floods the evaporator with liquid refrigerant when compressor capacity tends to exceed the heat load on the evaporator. This corresponds to most high ambient temperature highway conditions. The relatively low pressure of liquid refrigerant in the evaporator outlet caused by relatively high compressor speeds and the resultant high withdrawal rate of refrigerant from the evaporator tends to open the expansion valve and increase evaporator pressure to prevent evaporator freeze up.

During operation of the air conditioning system when the automobile engine is near idling and thus the compressor speed is low, the heat load on the evaporator often exceeds the capacity of the compressor. This produces relatively low withdrawal flow rates from the evaporator and high refrigerant pressure at the evaporator outlet which tends to close the present expansion valve. Because the expansion valve passage may be completely closed under these conditions, it is desirable to provide a continually open leakage path in the expansion valve. Leakage of refrigerant will improve the performance of the refrigerating apparatus

when the automobile is idling and produce an acceptable cool air discharge temperature into the passenger compartment.

Therefore, it is an object of this invention to provide a refrigerant expansion valve to regulate the flow of liquid refrigerant into the evaporator to maintain pressure therein above a predetermined value to prevent the evaporator temperature from falling below 32° F.

It is a further object of this invention to provide a refrigerant expansion valve responsive to evaporator outlet pressure for supplying sufficient liquid refrigerant to the evaporator to prevent its temperature from falling below 32° F. even when the compressor is operating to withdraw refrigerant from the evaporator at a high rate.

Further objects and advantages of the present invention will be apparent from the following detailed description, reference being had to the accompanying drawing in which a preferred embodiment of the invention is clearly shown.

In the drawing:

FIG. 1 is a diagrammatic view of an automobile air conditioning system with the subject pressure responsive expansion valve;

FIG. 2 is a fragmentary vertical sectional view in two parts through the subject expansion valve and housing shown in FIG. 1; and

FIG. 3 is a plot of control pressure versus ambient temperature and head pressure.

Referring to FIG. 1, there is illustrated an automobile refrigerant compressor 10 provided with a pulley 12 adapted to be driven at a fixed speed ratio to the engine by a belt from a pulley on the front of the automobile engine crankshaft (not shown). The compressor 10 withdraws evaporated refrigerant through a suction conduit 14 and passes the compressed refrigerant through a discharge conduit 16 into an air cooled condenser 18 which is normally located in front of the automobile radiator.

The compressed refrigerant is cooled and liquified in the condenser 18 and flows therefrom through conduit 20 to a fitting 22 through which it discharges into a tubular vertical receiver housing 24. A circular valve seat member 26 is supported across the interior of the tubular receiver housing 24 between an inlet opening 28 and a fitting 30 adjacent an outlet opening 32 adapted to pass liquid refrigerant from the interior of housing 24 into an evaporator 34. Liquid refrigerant flows through a passage 36 in the valve seat member 26 from inlet opening 28 to outlet opening 32 and hence into the evaporator 34. An annular O-ring type seal 38 prevents refrigerant leakage therebetween. Likewise an O-ring seal 39 seals the connection between fitting 30 and the inlet of the evaporator 34.

The bottom end of housing 24 is covered by a plug 40 threadably secured to the housing 24 by rolled threads 42 in the end of the tubular housing 24. An annular O-ring seal 44 between the plug 40 and the housing 24 prevents fluid leakage therebetween.

A wall member or partition 46 is supported within and across the upper end of tubular housing 24 and separates its interior into a lower metering chamber portion 48 and an upper control chamber portion 50. Metering portion 48 has inlet opening 28, valve seat

member 26 and outlet opening 32 therein. The control portion 50 includes a fitting 52 about a passage 53 which is adapted to engage the outlet of the evaporator to cause refrigerant to flow from the evaporator into portion 50. An O-ring seal 54 seals the connection between fitting 52 and the evaporator outlet. Another fitting 56 about a passage 57 communicates the control portion with the suction conduit 14 to pass refrigerant from the control portion 50 and evaporator 34 to the compressor 10.

A flexible metal diaphragm 58 forms the upper surface of control chamber portion 50. The diaphragm 58 is fastened at its periphery between a back up plate 60 and the upper end 62 of the housing 24. The diaphragm 58 is exposed on one side 59 to refrigerant in chamber 50 from the evaporator outlet.

A reference pressure chamber 64 is formed on the upper side 65 of diaphragm 58 by a cup-shaped member 66 which is secured to the backup plate 60 and end 62 by brazing at 68. The reference pressure chamber 64 is either filled with air at atmospheric pressure with refrigerant or evacuated. A fitting 70 in member 66 is used to fill or evacuate the chamber 64. A spherical valve member 72 seals chamber 64. A compression type coil spring 74 is supported between the upper portion of member 66 and the outer periphery of a plate 76. The center of plate 76 contacts the center portion of the diaphragm 58. Fluid pressure in chamber 64 and the spring 74 exert substantially constant pressure downward upon the upper side 65 of diaphragm 58 against which refrigerant pressure from the evaporator outlet exerts a force in an upward direction on the lower side 59 of diaphragm 58 to establish an equilibrium position. When the refrigerant pressure in the evaporator outlet increases, the diaphragm 58 moves upward against the force of the coil spring 74 and as refrigerant pressure from the evaporator outlet decreases, the diaphragm 58 moves downward.

Upward and downward movements of the diaphragm 58 within the tubular housing 24 in response to pressure changes in control chamber 50 are transmitted to an expansion valve member 78 adjacent the lower side of the valve seat member 26. Valve member 78 is threadably secured by a fastener 80 to the lower end of a valve rod 82 which extends upward through passage 36, tubular member 24 and a bore 83 in the wall member 46. A centering member 94 supports the lower end of valve rod 82 centrally within passage 36. An opening 96 in member 94 admits refrigerant from inlet 28 to passage 36. A diaphragm follower member 84 is threadably secured at its lower end to the valve rod 82 and contacts the center portion 86 of diaphragm 58 at its upper end. An annular seal member 88 is centrally secured between the diaphragm follower 84 and the valve rod 82 and its peripheral edge is connected to the wall member 46 by an annular plate 90 and fasteners 92. Seal 88 prevents refrigerant leakage between metering portion 48 and control portion 50.

When refrigerant pressure within the control chamber 50 decreases which corresponds to a pressure decrease within the evaporator, diaphragm 58 moves downward against the follower 84 and valve rod 82 to move the valve member 78 to a more open position. When refrigerant pressure in control portion 50 increases which corresponds to a pressure increase

within the evaporator 34, the diaphragm 58 moves upward against the force of spring 74 and the fluid force in chamber 64 to move the valve element 78 to a more closed position toward the lower end of the valve seat member 26.

In operation of the refrigerating apparatus, high pressure liquid refrigerant from the condenser 18 is expanded to a low pressure condition subsequent to passage through opening 36. Refrigerant which flows from passage 36 to the evaporator passes through a bag 98 of desiccant material to absorb moisture from the refrigerant.

As previously stated, the subject expansion valve is responsive to evaporator refrigerant pressure to open and close the expansion valve when the evaporator outlet pressure changes. Expansion valves which are responsive to the refrigerant temperature at the evaporator outlet, maintain a superheat temperature of refrigerant. Superheat is a measure of the temperature of a vapor above its boiling point at a given pressure. The present expansion valve does not always maintain superheat. When compressor capacity tends to exceed the heat load on the evaporator which condition corresponds to most high ambient temperature highway conditions, the expansion valve opens to flood the evaporator with liquid refrigerant. This has an advantage when used with parallel finned tube type evaporators. The evaporators have a tendency to develop hot spots caused by the formation of superheated vapor on one side of the core and liquid refrigerant on the other. The liquid refrigerant flooding of the evaporator caused by opening of the expansion valve tends to wash out the hot spots.

Under conditions of high evaporator load, and low compressor speed which often occurs when the motor vehicle is idling, the expansion valve tends to close due to a pressure increase in the evaporator. This maintains evaporator pressure above that needed to prevent frost accumulation on the evaporator. However, expansion valve closing may not provide enough refrigerant flow through the evaporator to maintain a minimum cool air discharge temperature into the passenger compartment. Thus, a small continually open passage 100 may be provided in member 26 to allow leakage of enough refrigerant to the evaporator for minimum cooling.

The refrigerant used in many automobile air conditioning systems is Refrigerant 12, a fluorocarbon compound with the general formula CCl_2F_2 . It changes from a liquid to a vapor or boils at a temperature slightly above 32° F. under a pressure of about 28 psig. It is desirable to maintain the refrigerant pressure in the evaporator above 28 psig to prevent the evaporator temperature from falling below 32° F. and resultant frost accumulation on the evaporator.

Normally, the present pressure responsive expansion valve controls refrigerant flow into the evaporator for maintaining at least a 28 psig pressure level therein to prevent freezing evaporator temperatures. As the ambient temperature increases, however, it has been observed that evaporator pressures lower than 28 psig can be tolerated without frost formation. This is partially explained by the increased rate of heat input to the evaporator due to an increased temperature difference between the faces of the evaporator under higher ambient temperature conditions. FIG. 3 illustrates this ob-

servation which illustrates the relation of control pressure in chamber 50 to ambient temperature for a given evaporator and refrigerant system. The broken line represents the evaporator freeze line below which frost will accumulate at corresponding control pressures and ambient temperatures. It is known that refrigerant head pressure at the condenser outlet is nearly independent of automobile speed but is proportional to changes in ambient temperature. Thus, increased ambients will produce proportionate increases in head pressures over a given speed range. This relation explains the dual labeling of the horizontal axis of the graph in FIG. 3.

The subject expansion valve utilizes the relation between ambient temperature and head pressure to decrease the effective control pressure and thus the pressure of refrigerant maintained in the evaporator with increases in head pressure at the inlet of the expansion valve. Specifically, the area of the seal member 88 exposed to head pressure in the metering portion is made slightly greater than the area of the valve member 78 exposed to head pressure. Thus the net force due to head pressure acting on the valve rod 82 is upward and the force increases with increases in head pressure. This upward force tending to close the valve passage 36 is supplementary to the control pressure force in chamber 50 and effectively reduces the control pressure maintained in the chamber for any given position of valve element 78. Thus at relatively low head pressures which correspond to low ambients only a relatively small supplemental force is applied to valve rod 82 and the evaporator pressure is maintained above 28 psig. At relatively higher head pressures corresponding to higher ambient temperatures, a larger supplemental force on rod 82 is applied which effectively lowers the control pressure and evaporator pressure below 28 psig. The control pressure relation to ambient temperature for a given compressor speed is shown in solid line in FIG. 3. The relative areas of seal 88 and valve element 78 can be modified to produce a desirable control pressure profile nearly paralleling the evaporator freeze line (broken line) as in FIG. 3.

While the embodiment of the invention as herein described and illustrated in the drawings constitutes a preferred form, it is to be understood that other forms might be adapted.

What is claimed is as follows:

1. Refrigerating apparatus for an automobile air conditioning system comprising: an evaporator with an inlet and an outlet; a tubular housing having openings connected to said evaporator inlet and evaporator outlet; wall means supported within the interior of said tubular housing for separating it into a control portion fluidly connected to said evaporator outlet and a metering portion fluidly connected to said evaporator inlet; means including a condenser and an inlet opening in said tubular housing for fluidly connecting said metering portion with the high pressure outlet of a compressor; means including an outlet opening in said tubular housing for fluidly connecting said control portion with the low pressure inlet of the compressor; a valve seat member supported within the interior of said tubular housing and separating said inlet opening and said evaporator inlet having a passage therein for the passage of refrigerant from said condenser to said evaporator; a valve rod with a valve member supported

adjacent said passage and adapted to coact with said valve seat member for controlling the quantity of refrigerant passing through said passage into said evaporator; an elongated valve rod connected at one end to said valve member and extending from said valve member through said passage, said metering portion and said wall means into said control portion; a movable seal between said valve rod and said wall means to prevent refrigerant flow between said control and metering portions and allowing movement of said valve rod with respect to said wall means; said valve member being exposed on one end to the relatively high pressure refrigerant from the condenser which produces an opening force on said valve member; said movable seal having one surface exposed to the relatively high pressure refrigerant from the condenser which produces a closing force on said valve rod and valve member; the area of said movable seal which is exposed to high pressure refrigerant from the condenser being greater than the area of said valve member exposed which produces a resultant closing force on said valve member which increases with increasing condenser outlet pressure; a diaphragm with one side exposed to refrigerant in said control portion from said evaporator outlet and a second side exposed to a substantially constant reference pressure; means including said valve rod for operably interconnecting said diaphragm and said valve member for closing and opening said passage in response to increasing and decreasing refrigerant pressure respectively in said control portion acting against one side of said diaphragm and for opening said passage in response to decreased refrigerant pressure acting against said one side.

2. Refrigerating apparatus for an automobile air conditioning system comprising: an evaporator with an inlet and an outlet; a tubular housing having openings connected to said evaporator inlet and evaporator outlet; wall means supported within the interior of said tubular housing for separating it into a control portion fluidly connected to said evaporator outlet and a metering portion fluidly connected to said evaporator inlet; means including a condenser and an inlet opening in said tubular housing for fluidly connecting said metering portion with the high pressure outlet of a compressor; means including an outlet opening in said tubular housing for fluidly connecting said control portion with the low pressure inlet of the compressor; a valve seat member supported within the interior of said tubular housing and separating said inlet opening and said evaporator inlet having a passage therein or the passage of refrigerant from said condenser to said evaporator; a valve member supported adjacent said passage and adapted to coact with said valve seat member for controlling the quantity of refrigerant passing through said passage into said evaporator; an elongated valve rod connected at one end to said valve member and extending from said valve member through said passage, said metering portion and said wall means into said control portion; a movable seal between said valve rod and said wall means to prevent refrigerant flow between said control and metering portions and allowing movement of said valve rod with respect to said wall means; said valve member being exposed on one end to the relatively high pressure

refrigerant from the condenser which produces an opening force on said valve member; said movable seal having one surface exposed to the relatively high pressure refrigerant from the condenser which produces a closing force on said valve rod and valve member; the area of said movable seal which is exposed to high pressure refrigerant from the condenser being greater than the area of said valve member exposed which produces a resultant closing force on said valve member which increases with increasing condenser outlet pressure; a diaphragm with one side exposed to refrigerant in said control portion from said evaporator outlet and a second side exposed to a substantially constant reference pressure; means including said valve rod for operably interconnecting said diaphragm and said valve member for closing said passage in response to increasing refrigerant pressure in said control portion acting against one side of said diaphragm; said valve seat member having a relatively small, continuously open bleed passage in bypass relation to said passage for supplying a minimum quantity of refrigerant to said evaporator when said passage is closed for producing cooling by the evaporator.

3. Refrigerating apparatus for an automobile air conditioning system comprising: an evaporator with an inlet and an outlet; a tubular housing having openings connected to said evaporator inlet and evaporator outlet; wall means supported within the interior of said tubular housing for separating it into a control portion fluidly connected to said evaporator outlet and a metering portion fluidly connected to said evaporator inlet; means including a condenser and an inlet opening

in said tubular housing for fluidly connecting said metering portion with the high pressure outlet of a compressor; means including an outlet opening in said tubular housing for fluidly connecting said control portion with the low pressure inlet of the compressor; a valve seat member supported within the interior of said tubular housing and separating said inlet opening and said evaporator inlet forming a passage therein for the passage of refrigerant from said condenser to said evaporator; a valve member supported adjacent said passage and adapted to coact with said valve seat member for controlling the quantity of refrigerant passing through said passage into said evaporator; an elongated valve rod connected at one end to said valve member and extending from said valve member through said passage and said wall means into said control portion; a movable seal between said valve rod and said wall means to prevent refrigerant flow between said control and metering portions and allowing lateral movement of said valve rod with respect to said wall means; said seal being exposed to high pressure refrigerant in said metering portion from said compressor to exert a closing force upon said valve member; a diaphragm with one side exposed to refrigerant in said control portion and a second side exposed to a reference pressure; means including said valve rod for operably interconnecting said diaphragm and said valve member for closing and opening said passage in response to increasing and decreasing refrigerant pressure respectively acting against the one side of said diaphragm.

* * * * *

35

40

45

50

55

60

65