United States Patent

Proctor

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[54] **REFRIGERANT EVAPORATOR TEMPERATURE CONTROL**

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[73] Assignee: **American Standard Inc.**, New York, N.Y.

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Related U.S. Application Data

[63] Continuation of Ser. No. 795,828, Feb. 3, 1969, abandoned.

[52] **U.S. Cl.** **62/212**, 62/217, 62/225
[51] **Int. Cl.**.....**F25b 41/00**
[58] **Field of Search**.....62/204–212, 217, 62/225

[56] **References Cited**

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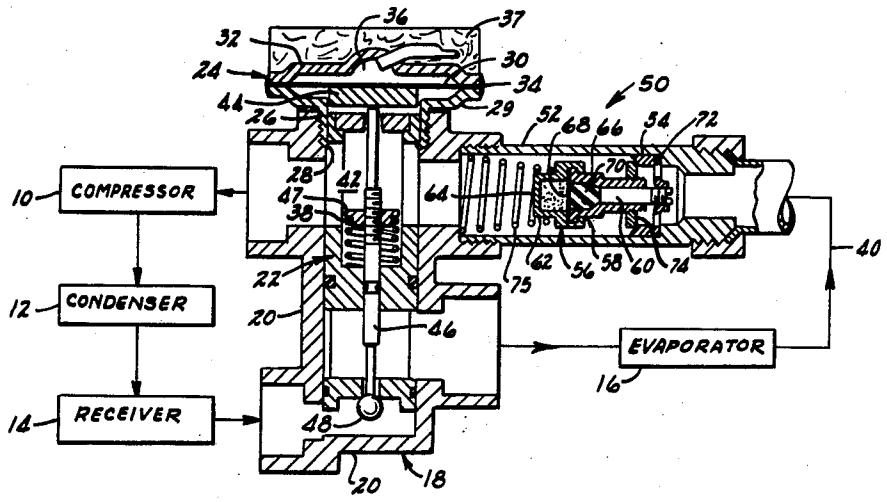
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[57] **ABSTRACT**

An automotive air conditioner system having a temperature-responsive power means in the refrigerant suction line for throttling refrigerant flow from the evaporator when the evaporator temperature drops toward a value low enough to cause ice formations on the evaporator fin surfaces; the power means is preferably located upstream from the actuator means of a thermostatic expansion valve so that the throttling action reduces the pressure at the actuator means and causes the actuator means to respond to relatively high superheat, thereby requiring the expansion valve to flood the evaporator in a manner to temporarily raise the pressure and temperature within the evaporator for de-icer action.

10 Claims, 3 Drawing Figures



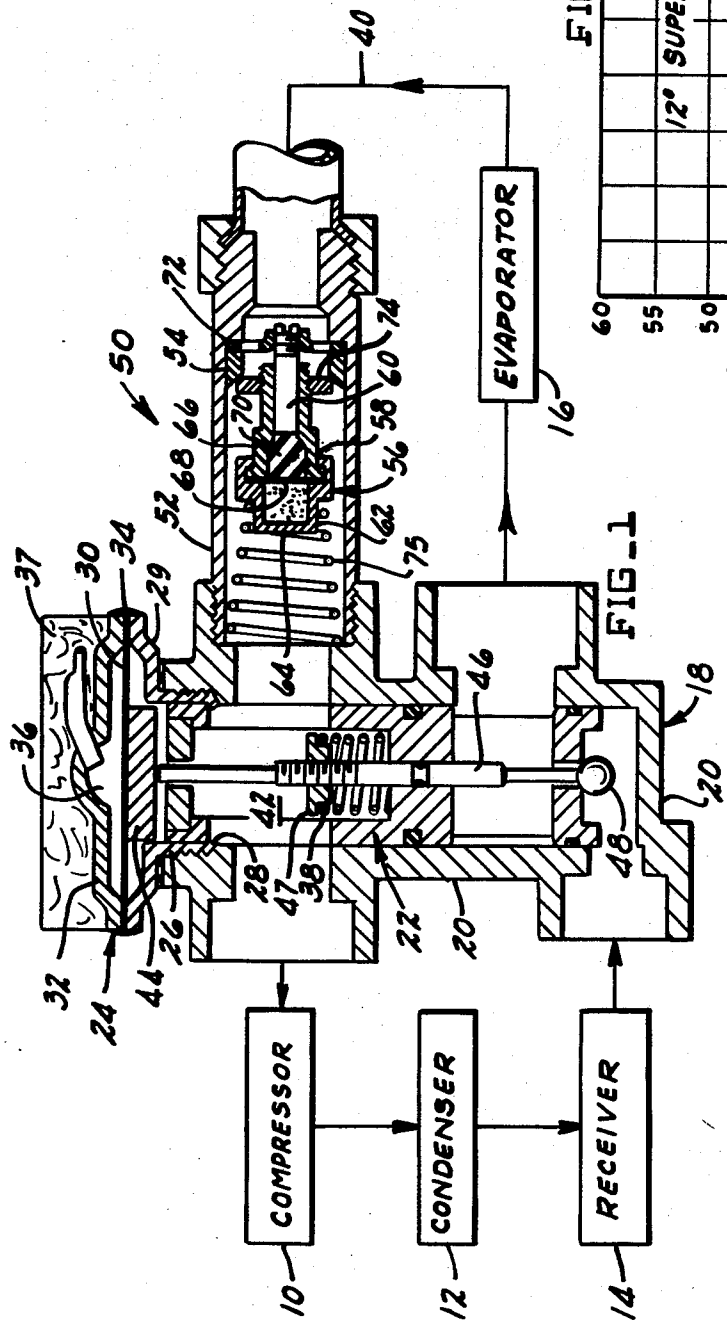


FIG_1

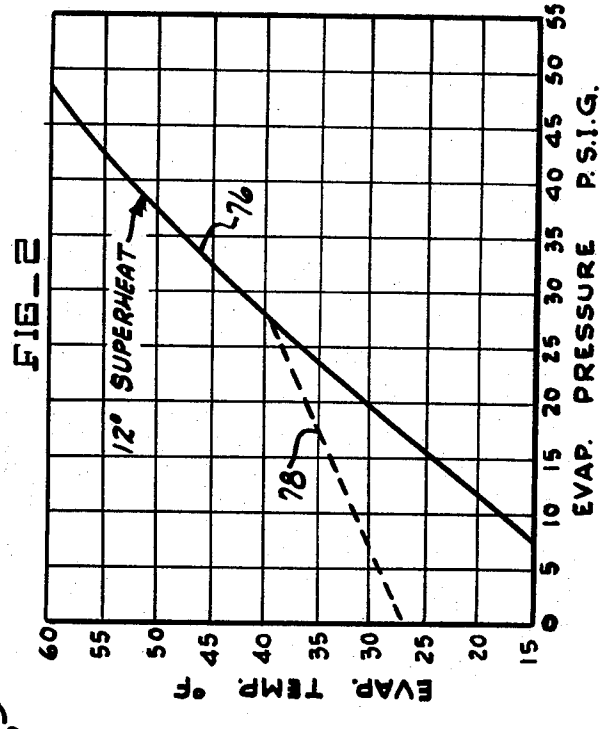


FIG_2

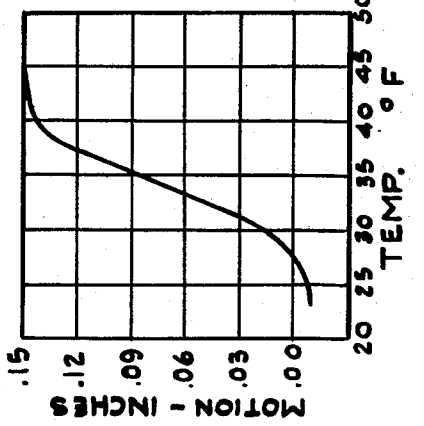


FIG_3

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REFRIGERANT EVAPORATOR TEMPERATURE CONTROL

This application is a continuation of U.S. Application Ser. No. 795,828, Refrigerant Evaporator Temperature Control, filed Feb. 3, 1969 and now abandoned.

THE DRAWINGS

FIG. 1, partly schematic, shows one form in which the invention can be practiced.

FIG. 2 is a chart showing temperature-pressure conditions in a system using the FIG. 1 apparatus.

FIG. 3 is a temperature-motion diagram for a thermostatic power means usable in the FIG. 1 apparatus.

THE DRAWINGS IN DETAIL

There is shown an automotive air conditioner system comprising a refrigerant compressor **10** driven from the engine by a clutch (not shown), a refrigerant condenser **12**, receiver **14**, expansion valve **18** and evaporator **16**. Valve **18** comprises a ported body **20** permanently assembled into the refrigerant system, and a removable valve cartridge **22** having a thermostatic actuator means **24**.

Actuator means **24** includes a sleeve **26** permanently affixed to the cartridge, as by the staking at **28**, a lower cap **29**, a metallic diaphragm **30**, and an upper cap **32**, the various members being welded together by a continuous peripheral weld **34**. The space between diaphragm **30** and cap **32** is occupied by a thermally expansible material **36**, for example the same material used in the refrigerant system. Thermal insulation is provided at **37** to insulate the charge from the ambient temperature.

SUPERHEAT CONTROL

During operation of the system the refrigerant issues from the evaporator outlet in gaseous form at a superheat determined by the adjustment of a spring **38** within the expansion valve. The superheat control occurs as a result of the opposing forces produced by thermal expansion of the charge **36** and spring **38**, plus the pressure in chamber **42** acting on the diaphragm **30**. Relatively high temperature gas in suction line **40** flows through chamber **42** in valve **18** and heats or cools the pad **44** carried by diaphragm **30**, thereby causing thermal charge **36** to produce a proportionate downward force on the valve stem **46**. Spring **38** develops an opposing upward force on the nut **47** and the stem **46**, so that any movement of the metering valve element **48** is a function of the suction line temperature, all as conventional in the art. Variation in superheat setting can be achieved by turning nut **47** on the stem.

SUCTION LINE THROTTLING AT 74

The present invention most particularly concerns a throttling mechanism **50** located in the suction line upstream from chamber **42**. As shown, the mechanism includes a housing **52** screwed into valve body **20**, and operatively mounting a valve seat **54**. Located on the downstream side of seat **54** is a temperature-responsive power means **56** comprising a container **58**, piston **60**, and a pellet-like mass of temperature-sensitive material **62**. Container **58** includes a cup-like element **64** and sleeve-like cover **66** suitably connected together for retention of an elastomeric diaphragm **68** and plug **70** in sealing relation to the pellet material **62**. In operation, temperature increase of the vapor surrounding cup **64** causes the pellet **62** to transform from the solid state to the liquid state, thereby expanding to produce pressures on the diaphragm **68** sufficient to move plug **70** bodily outwardly relative to sleeve **66**. Sleeve **66** is arranged as a slide fit on a piston **60** which is suitably anchored on a spider **72** carried by housing **52**. Therefore the net effect of pellet **62** expansion is to produce a leftward movement of container **58** and the poppet valve element **74** carried thereby. Temperature decrease in the vapor surrounding cup **64** produces pellet **62** contraction, which allows the compression spring **75** to return the container **58** and poppet element **74** toward its illustrated position.

PELLET EXPANSION

Pellet **62** preferably includes a mass of wax which undergoes solid-liquid transition in a temperature range near or spanning 32° F, as for example completely solid at 28° F and completely liquid at 39° F. Suitable waxes are commercially available for solid-liquid expansion in the desired range; such waxes are mixtures of different hydrocarbons which produce the effective transition in wider or narrower temperature ranges according to composition of the pellet as determined by the initial fractionating and compounding, all according to known practice in the art. FIG. 3 illustrates the temperature-motion curve of a thermostatic power means useful in practice of the invention.

Pressures produced by pellet **62** expansion can be comparatively high, as for example over 2,000 p.s.i., if the expansion process is resisted, as by holding the piston and container in their start positions. In the actual installation the pellet pressures may reach fairly high values since the piston and container are restrained by the spring **75** and the radial friction loads between plug **70** and sleeve **66**, plus the pressure difference across the valve due to the throttling action at **74**. The capability of the pellet for producing relatively high forces is important in that it allows the temperature-responsive power means to move only as a function of the suction line temperature without in any way being influenced by variations in suction line pressure. Suction line pressures are usually relatively low, on the order of 50 p.s.i. or less.

SYSTEM OPERATION

During operation of the illustrated system the throttling element **74** will exert no throttling effect as long as the suction line temperature is above 39° F; element **74** is then spaced leftwardly away from seat **54**. Should the temperature drop below 39° F element **74** will exert a progressively greater throttling effect according to how much the temperature drops; at 28° F the element will close against seat **54**, thereby completely interrupting refrigerant flow from the evaporator to the compressor.

Compressor **10** is usually running on a continuous basis as long as the vehicle engine is running and the occupant has turned the air conditioner switch to the on position. On a continuous run basis for the compressor, the actual temperature in the passenger space will be controlled by dampers and/or variable speed fans operating on the airstream flowing across the evapora-

tor. Assuming sufficient demand for air cooling, the evaporator will be at a high enough temperature to prevent any icing on its fin surfaces. However during low demand periods less refrigerant will be evaporated in the evaporator, and the continuously-running compressor will tend to reduce the pressure and temperature in the suction line and evaporator, all in accordance with curve **76** of FIG. **2**.

If mechanism **50** were not in the system the evaporator temperature could well drop below 32° F; ice might then form on the fin surfaces. However in actual practice ice at 32° F is rather slushy or only temporarily on the fin surfaces due to air heating effects or air movement effects. Usually the fin temperature must get down to about 28° F before permanent ice formations occur; 28° F is therefore chosen as the temperature at which throttling mechanism **50** fully interrupts flow of refrigerant from the evaporator to the compressor.

In operation of the system with mechanism **50** installed therein, the system functions in the normal manner at evaporator temperatures above 39° F. However should the air-cooling demand be so reduced as to permit the compressor to lower the evaporator pressure below about 27 p.s.i.g. the corresponding drop in suction line temperature will cause material **62** to partially solidify so as to produce a throttling movement of poppet element **74** toward seat **54**. The throttling action will cause two things to happen, as follows: (1) the pressure in the evaporator will be higher than if no throttling had taken place, and (2) the superheat in chamber **42** will be somewhat higher than otherwise.

LOCATION OF THROTTLING DEVICE

It is preferred that throttling mechanism **50** be located on the upstream side of chamber **42** to wholly or partially isolate the thermal charge **36** from the evaporator temperatures during the throttling periods. This isolation effect is advantageous in that charge **36** assumes an artificially high superheat for more fully opening the metering element **48**. The action tends to produce a flooding action in the evaporator, both because element **48** is feeding the evaporator with liquid and because element **74** is restricting the escape of vapor from the evaporator. Such flooding tendency raises the evaporator pressure and evaporator temperature, thus producing a de-icing and/or icer-prevent action on the evaporator surfaces, the temperature-pressure relationship following generally along line **78** in FIG. **2**.

It will be understood that the operation is a modulating action wherein throttling and pressure-temperature changes may be gradual without full throttling or full opening of element **74**. Also, the described temperatures of 28° F full-closed and 39° F full-open are somewhat arbitrary; useful results may be achieved using different temperature ranges. In general however it is preferred to choose temperatures which are just above the evaporator fin icing level; this lets the evaporator have more cooling capacity with a given surface area, thereby permitting a smaller evaporator for a given duty.

FORCE REQUIREMENT

It is of some importance that power means **56** be insensitive to pressure variations in the suction line, and that power means **56** have sufficient force capability to open and close the throttling element **74** independent of the pressure drop across seat **54**. If a low force power means such as a bimetal or liquid-charged bellows were used in lieu of power means **56** the pressure drop across the valve seat would tend to increase the throttling effect to an undesirable extent, sufficient to prevent normal operation of the system. Therefore the thermostatic power means must be pressure-insensitive for proper results.

The drawings show power means **56** as a wax-charged element wherein temperature decrease produces contraction of pellet **62**. It is contemplated that the charge could be water instead of wax, in which case a temperature decrease to a value below approximately 32° F would produce a change of state from liquid (water) to solid (ice) with an accompanying expansion of the charge. The relationship between the valve element and seat would be such as to produce throttling on expansion of the charge.

I claim:

1. In a refrigerant system which includes a continuously running refrigerant compressor, condenser, evaporator, refrigerant metering means between the condenser and evaporator, and a suction line between the evaporator and compressor: the improvement comprising a throttling means in the suction line, and temperature-responsive power means having a movable output member for operating said throttling means in accordance with variations in suction line temperature; said power means being constructed so that its output member moves solely as a function of the suction line temperature without being influenced by section line pressure; said power means comprising a contained mass of temperature-sensitive material which undergoes transformation between the solid and liquid states in a temperature range in the vicinity of 32° F, whereby the output member enjoys movement in such a temperature range; said power means and throttling means being connected so that the throttling means increases its throttling action as the temperature drops within said range, and so that the throttling means reduces its throttling action as the temperature rises within said range.

2. The system of claim **1** wherein the power means comprises a movable container for the mass of temperature-sensitive material, and a fixed piston slidably projecting into the container, whereby expansion of the material causes movement of the container; the aforementioned throttling means comprising a flow-throttling element carried by the container.

3. The system of claim **2** wherein the flow-throttling element is carried by a portion of the container located upstream from the temperature-sensitive material, whereby the suction line fluid washes the sensitive material after movement past the throttling element.

4. The system of claim **1** wherein the refrigerant metering means comprises a thermostatic expansion valve having a temperature-responsive actuator means controlled by suction line temperature; the aforementioned temperature-responsive power means being located upstream from the actuator means, whereby movement of the throttling means toward a no-flow position causes the actuator means to temporarily respond to a synthetic superheat.

5. The system of claim 4 wherein the thermostatic expansion valve comprises a valve body having a chamber therein which constitutes part of the suction line, said actuator means being located in thermal engagement with said chamber; the aforementioned power means-throttling means assembly being constructed as an insert device attached directly to the expansion valve body immediately upstream from the aforementioned chamber.

6. A closed refrigerant system wherein a thermostatic expansion valve controls the flow rate of liquid refrigerant entering the evaporator in response to the superheat of the refrigerant gas leaving the evaporator, including a throttling valve which is responsively controlled by a decrease in the temperature alone of the refrigerant in the suction line to throttle the flow of refrigerant leaving said evaporator so that the refrigerant in said evaporator is prevented from falling below a predetermined temperature which could allow the formation of ice in said evaporator.

7. A closed refrigerant system wherein a thermostatic expansion valve controls the flow rate of liquid refrigerant entering the evaporator in response to the superheat of the refrigerant gas leaving the evaporator, including a throttling valve having a temperature responsive power means and a mechanical valve means disposed internally of the suction line leading from the evaporator, which is responsively controlled by a decrease in temperature alone of the refrigerant in the suction line to throttle the flow of refrigerant leaving said evaporator so that the refrigerant in said evaporator is prevented from falling below a predetermined temperature which could allow the formation of ice in said evaporator.

8. The closed refrigerant system as defined in claim 7, wherein said temperature responsive power means includes a thermal sensitive material and at least one relatively movable element.

9. The closed refrigerant system as defined in claim 8, wherein said thermal sensitive material is a mass of substance which undergoes a transition when the suction line temperature decreases thereby causing movement of said movable element.

10. A closed refrigerant system wherein a thermostatic expansion valve controls the flow rate of liquid refrigerant entering the evaporator in response to the superheat of the refrigerant gas leaving the evaporator, including a throttling valve which is responsively controlled by a decrease in temperature alone of the refrigerant in the suction line to throttle the flow of refrigerant leaving said evaporator so that the refrigerant in said evaporator is prevented from falling below a predetermined temperature which could allow the formation of ice in said evaporator, said thermostatic expansion valve and said throttling valve being formed as a single unit.

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