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Proctor

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[54] **TEMPERATURE RESPONSIVE THROTTLING VALVE**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 75,713, Sept. 25, 1970, Pat. No. 3,691,783, which is a continuation of Ser. No. 795,828, Feb. 3, 1969.

[52] **U.S. Cl.** **236/34,** 62/212, 62/217, 62/224

[51] **Int. Cl.** **F25b 41/04**

[58] **Field of Search** 236/92, 93, 99, 100, 236/101, 34, 34.5

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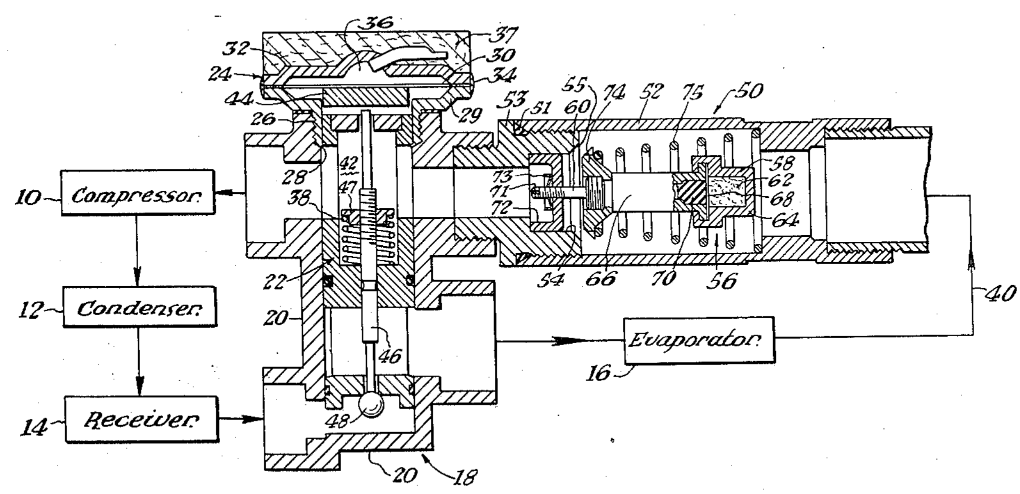
[57] **ABSTRACT**

The present disclosure relates to an automotive air conditioner system which is arranged to have a throttle valve including a temperature-responsive power operating means situated 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 formation on the evaporator fin surfaces. The throttle valve is preferably but not necessarily located upstream of the actuator means of the thermostatic expansion valve. The power operating temperature responsive means includes a wax filled container and a slidable piston which cooperatively move a valve member toward a valve seat when the temperature of the refrigerant in the suction line decreases to a moisture freezing level. The throttling effect prevents the compressor from pulling down the pressure and temperature within the evaporator to a level where ice or frost could form on the surfaces of the fins of the evaporator.

9 Claims, 3 Drawing Figures



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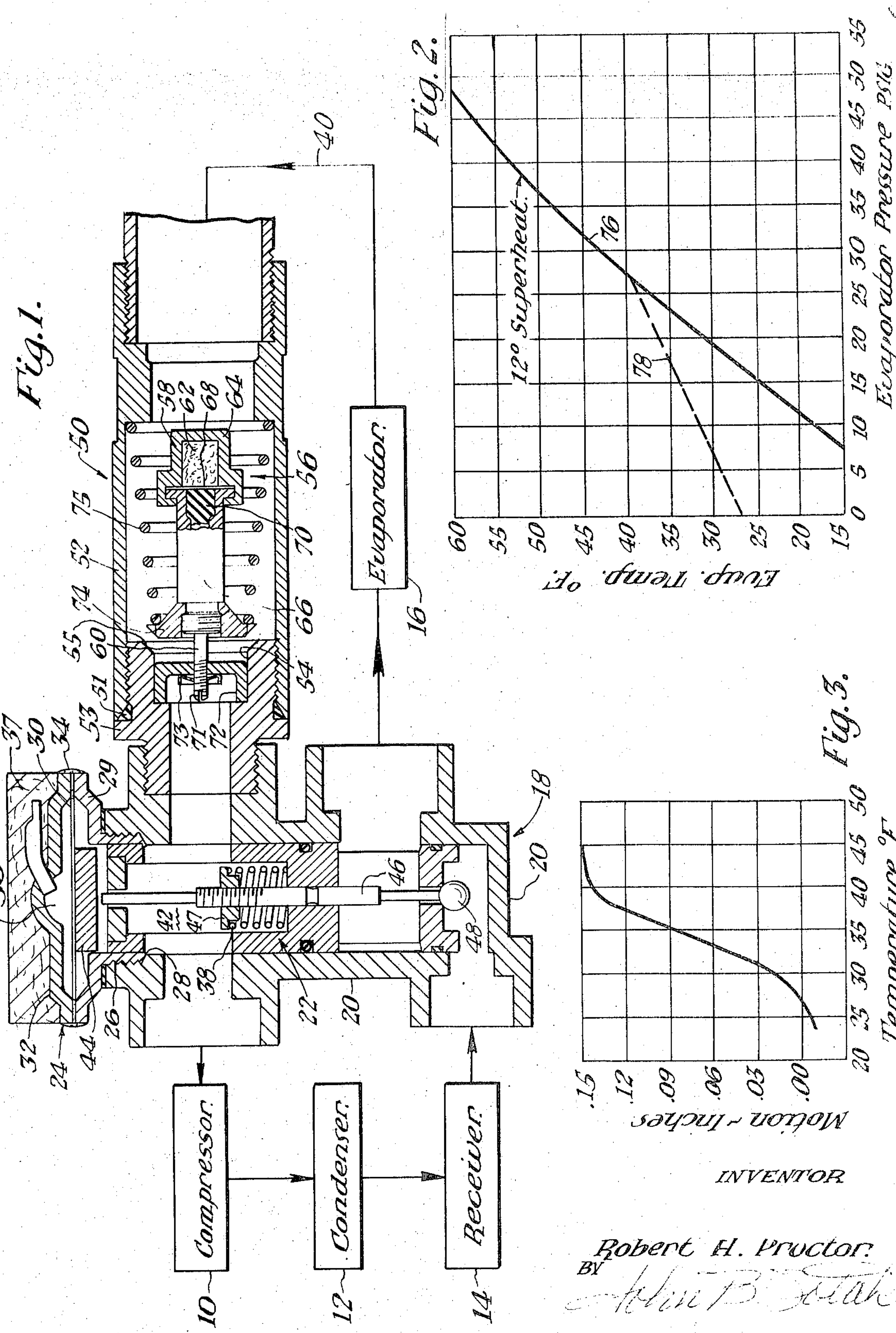

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BY

TEMPERATURE RESPONSIVE THROTTLING VALVE

This application is a continuation-in-part of application Ser. No. 75,713, filed Sept. 25, 1970 for Refrigerant Evaporator Temperature Control now U.S. Pat. No. 3,691,783 issued Sept. 19, 1972 which, in turn was a continuation of Ser. No. 795,828, filed Feb. 3, 1969 for Refrigerant Evaporator Temperature Control and now abandoned.

This invention relates to an improved throttling valve, and more particularly to a throttle valve for throttling the flow of refrigerant leaving an evaporator of a refrigerating system so that ice is prevented from being formed on the surfaces of the fins of the evaporator during high humidity and low load demand conditions.

In refrigerating systems, such as automotive air conditioners, frost or ice formation of the surfaces of the fins of the evaporator results in inefficient operation as well as causes an annoyance to vehicle owners. Since an automotive air conditioner is exposed to all types of environmental conditions and is required to operate under various load demands at a wide range of engine speeds, it was common for the evaporator to become iced and frosted. This frosted condition normally occurs when the humidity is relatively high and when the load demand is decreased. Under these circumstances, the decrease in load causes the pressure of the evaporator to be sharply pulled down by the compressor. The drop in evaporator pressure is accompanied by a drop in temperature of the refrigerant which at approximately 32° F allows the moisture in the air to form frost and ice on the fins of the evaporator. If the build-up continues, the fins will eventually become completely clogged with ice so that no air will be able to pass through the evaporator and substantially no cooling will result from the air conditioner. In order to prevent such adverse operations, it is necessary to preclude a pressure drop in the evaporator during reduced load demand periods. It has been found that by measuring the temperature of the refrigerant flowing in the suction line, it is possible to prevent ice from forming on the evaporator by a throttling operation. That is, if a suitable temperature responsive throttle valve is placed in the suction line, throttling action is arranged to begin at approximately 39° F and continues so that no further drop in evaporator pressure and no further accompanying drop in temperature of the refrigerant can be caused by the lightly loaded compressor. Thus, the temperature of the evaporator can be maintained above the level at which the moisture of the air could form ice and frost on the surfaces of the fins.

Accordingly, it is an object of this invention to provide a temperature responsive throttling valve for regulating the flow of fluid refrigerant in an air conditioner system.

Another object of this invention is to provide a throttling means in the suction line of a refrigerating system having a continuously running refrigerant compressor, condenser, evaporator, refrigerant meter means between the condenser and evaporator.

A further object of this invention is to provide a throttling valve which is responsively controlled by a decrease in temperature of the refrigerant in the suction line for throttling the flow of refrigerant leaving the evaporator in order to prevent the formation of ice thereon.

Yet another object of this invention is to provide a new and improved valve which is temperature responsive to throttle the flow of fluid.

Yet a further object of this invention is to provide a throttle valve which is responsive to a decrease in temperature to throttle the flow of a fluid.

Still another object of this invention is to provide a throttle valve having a temperature responsive power operating means for controlling the flow of refrigerant in a closed refrigerating system.

Still a further object of this invention is to provide an evaporator temperature regulator which throttles the refrigerant leaving the evaporator in accordance with the temperature of the refrigerant so that ice will not be formed on the surfaces of the fins of the evaporator.

Still yet another object of this invention is to provide a throttle valve having a temperature sensitive power operating means which includes a container and a slidable piston which cooperatively move a valve member toward a valve seat when the temperature of a fluid decreases within a temperature range and which cooperatively move the valve member away from the valve seat when the temperature of a fluid increases within the temperature range.

Still yet a further object of this invention is to provide a temperature responsive throttle valve for a refrigerating system which is economical in cost, simple in construction, reliable in operation, durable in use and efficient in service.

In accordance with the present invention, a throttle valve is situated in the suction line of an air conditioner system having a continuous running refrigerant compressor, a condenser, an evaporator and refrigerant metering device located between the condenser and evaporator. The throttle valve includes a cylindrical valve body having an inlet and an outlet. A temperature responsive power operating means includes a container and slidable member which are fixedly mounted within the valve body. The container includes a mass of temperature sensitive material which expands and contracts in accordance with temperature changes which thereby allows relative movement to occur between the container and the slidable member. A valve member is carried by the power operating means and an associated valve seat is disposed within the valve body. The valve member is constantly urged toward the valve seat by biasing spring. During normal operation, the valve member is unseated due to the expanded condition of the mass of temperature sensitive material which overcomes the efforts of the biasing spring and extends the slidable member. However, when the temperature of the refrigerant in the suction line drops to a preselected level the mass of temperature sensitive material contracts and the spring depresses the slidable member into the container and urges the valve member toward the valve seat so that flow of refrigerant from the evaporator is throttled. The throttling action prevents the compressor from reducing the pressure and temperature of the evaporator to a level where ice or frost could form on the fins of the evaporator.

The foregoing objects and other attendant features and advantages will be more readily appreciated as the subject invention becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

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.

In viewing the drawings, and in particular FIG. **1**, there is shown an automotive air conditioner system comprising a refrigerant compressor **10** driven from the engine through a suitable 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**. The 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.

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 the body **20** and caps **29** and **32** as well as the pad **44** carried by diaphragm **30**, thereby causing thermal charge **36** to produce a proportionate downward force on the valve stem **46**. It will be appreciated that an upward force is exerted on the valve stem **46** when the temperature of the superheat decreases. 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.

A throttling mechanism or throttle valve **50** is located in the suction line upstream from chamber **42**. As shown, the valve includes a cylindrical metallic body or housing **52** having an inlet end internally threaded to receive the suction line **40**. The outlet end of the valve body **52** is also internally threaded to receive an apertured plug or fitting **53** which is adapted to be threadedly screwed into the thermostatic expansion valve body **20**. An O-ring **51** is located between the contiguous surfaces of the plug **53** and valve body **52** to prevent refrigerant from leaking thereby. The plug **53** includes an internally enlarged portion **54** and a tapered annular portion **55** which forms the valve seat, as will be described presently.

Located on the upstream side of valve seat **55** is a temperature-responsive power operating means **56** comprising a container **58**, a piston **60**, and a pellet-like mass of temperature-sensitive material **62**. Container **58** includes a cup-like element **64** and sleeve-like cover or tubular guide **66** suitably connected together for retention of an elastomeric diaphragm **68** and plug **70** in sealing relation to the pellet meterial **62**. In operation, any temperature increase of the refrigerant 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**. The piston is arranged to slide fit in the tubular guide **66** and is adapted to move between a compressed and protracted position in response to the expansion and contraction of the pellet **62**. The free end of a piston is threaded as shown at **71** and is screwed into the central aperture of a spider member **72**. The free end of piston **71** includes a slot which allows for calibration of the valve setting and after the necessary adjustments have been made a lock or retention nut **73** is screwed into the threaded portion of piston **71**. The spider **72** is preferably cup-shaped and includes a number of radially extending legs, and outer extremities of which join with a substantially wider annular flange. The spider **72** is preferably stamped of sheet metal or the like and is press fitted into the enlarged aperture **51** of plug **50**. A relatively tight fit is ensured by the fact that a substantially large surface area is provided by the annular flange of the spider **72**. A poppet valve element or member **72** is screwed onto the threaded portion provided on the free end of tubular guide **66**. The surface of the valve member **74** adjacent the plug **53** is also tapered to match tapered valve seat **55**. A compression spring **75** is disposed between the inner surface of the valve member **74** and the inner wall formed on the inlet end of the valve body **52**. The compression spring **75** effectively surrounds the power operating means so that no additional space or length is required. The compression spring **75** is arranged to normally urge or bias the valve member **74** toward its closed position. Under normally operating conditions, the piston **71** is extended due to the liquified expanded pellet **62** so that the valve member **74** is unseated from the valve seat **55**, as shown in FIG. **1**. Now when the temperature of the refrigerant vapor surrounding cup **64** decreases the pellet **62** will begin to solidify and contract thereby allowing the compression spring **75** to depress the piston **71** into the container **58** so that valve member **74** moves toward the valve seat **55**.

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.

During operation of the illustrated system, the throttling element **74** will exert little, if any throttling effect as long as the suction gas temperature is above 39° F; valve member **74** is then spaced rightwardly away from seat **55**, as shown. Should the temperature of the refrigerant in the suction line **40** drop below 39° F, valve member **74** will exert a progressively greater throttling effect according to how much the temperature drops, and at approximately 28° F, the member **74** will move in the direction of seat **55**, thereby throttling 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 can be controlled by dampers and/or variable speed fans operating on the air-stream flowing across the evaporator or reheat from any suitable source, i.e., engine cooling water, condenser cooling water, heat rejected into the condenser cooling air or any other convenient means. Assuming sufficient demand for air cooling, the evaporator **16** 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 the throttling valve mechanism **50** were not in the system the evaporator temperature could well drop below 32° F so that ice and frost would tend to form on the fin surfaces. The drop in temperature is due to the fact that the compressor **10** would keep pulling down the pressure of the evaporator **16** so that a resulting drop in temperature would occur. 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 and frost formations occur; 28° F is therefore chosen as the temperature at which throttling mechanism **50** controls the 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 or load be so reduced as to permit the compressor to lower the evaporator pressure below about 27 p.s.i. the corresponding drop in suction line temperature will cause material **62** to partially solidify so as to produce a throttling action by movement of poppet element **74** toward seat **55**. The throttling action will cause several things to happen, as follows: first, the pressure in the evaporator will be higher than if no throttling had taken place, and second, the superheat in chamber **42** will be somewhat higher than otherwise when chamber **36** is system charged. Thus, the throttling valve mechanism **50** prevents the compressor **16** from reducing the temperature of the evaporator **10** to a level which would cause ice and frost to form on the surfaces of the fins of the evaporator.

The throttling mechanism **50** may be located on either side of chamber **42** or may be situated in any convenient location in the suction line. It is preferred 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 temperature for more fully opening the metering element **48**. In addition, throttling reduces the pressure in chamber **42** which ordinarily tends to resist the downward pressure exerted by thermal charge **36**, dependent upon the material in charge **36**, to thereby increase the downward force on meter element **48** to allow more full opening of that element. 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 or vapor from the evaporator. Such flooding tendency raises the evaporator pressure and evaporator temperature, thus producing a de-icing and/or icer-present action on the evaporator surfaces. The temperature-pressure relationship will follow line **78** rather than the normal curve **76** as shown 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 temperature of 28° F normal full-throttle and 39° F normal 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.

It is of some importance that power operating means **56** be insensitive to pressure variations in the suction line, and that power operating means **56** have sufficient force capability to open and close the throttling element **74** independent of the pressure drop across seat **55**. 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 the 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 operating 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.

An advantage is realized by disposing the compression spring **75** between the valve member **74** and the inner wall of the inlet side of the valve body. It will be noted that a separate space is not required for the spring **75** since it effectively surrounds the power operating means **56**, and therefore, the length of the valve body **57** may be effectively shortened. Such a space saving feature is very desirable, particularly in, an automotive application where space is at a premium.

On hot days, the temperature under the hood of a motor vehicle may be 175° F or above which can cause the piston **71** to be extended beyond its normal length of travel. This over-travel does not adversely affect the unique arrangement as shown in FIG. **1** since the spring **75** will allow further movement of the power operating means **56** so that no damage will occur to the valve parts during periods of overheating.

It has also been found highly advantageous to place the container **64** adjacent to the inlet side of valve mechanisms rather than adjacent its outlet side. Further, with the disposition shown, the container is exposed to the suction line from the evaporator which is the condition to be sensed by the temperature sensitive material **62.** Thus, more effective results and quicker response to changing evaporator conditions will be produced with the power operating means disposed as shown.

An additional benefit of utilizing the throttle valve mechanism **50** is that the compressor **10** is not required to work as hard as compressors in previous refrigerating systems in that the head or discharge pressure of the compressor is reduced in proportion to the amount of throttling action.

It will be appreciated that while this invention finds particular utility in automotive air conditioner systems, it is readily evident that the invention is not limited thereto but may be employed in other refrigerating systems and in other environmental settings. It will also be apparent that various alterations, modifications and changes can be made to the presently described invention, and therefore, it is understood that all changes, equivalents, and modifications falling within the spirit and scope of the present invention are herein meant to be included in the appended claims.

Having thus described our invention what we claim is:

1. The combination for automatically regulating evaporator temperature in a refrigerating system of a throttle valve for throttling the flow of refrigerant fluid from an evaporator in a refrigerating system with refrigerant fluid metering means for controlling the flow of refrigerant fluid to an evaporator, said throttle valve comprising a valve body receiving said refrigerant fluid from an evaporator and, having openings near its opposite ends to allow flow of refrigerant fluid therethrough, a power operating means mounted within said valve

body, said power operating means including a container having a mass of material sensitive to a limited range of temperatures which expands and contracts in accordance with the temperature of the refrigerant fluid, said container being disposed directly in the path of flow of said refrigerant fluid through said valve body, so that said valve responds immediately to changes in temperature of said refrigerant fluid, said power operating means including a slidable member cooperatively associated with said container and arranged to be reciprocated in accordance with the expansion and contraction of said mass of said material sensitive to a limited range of temperatures, a valve member operated by said power operating means and arranged to move away from and toward a valve seat in accordance with the reciprocation of said slidable member, and a biasing spring normally urging said valve member toward said seat.

2. The combination of claim **1** wherein said container is disposed adjacent the opening in one end of said valve body and said valve member is disposed adjacent the opening in the opposite end of said valve body.

3. The combination of claim **1,** wherein said biasing spring is situated between said valve member and a wall formed near the opening in one end of said valve body and surrounds said power operating means.

4. The combination of claim **1,** wherein said slidable member is a piston having its free end connected to a spider member which is fitted into the opening at one end of said valve body.

5. The combination of claim **1,** wherein said valve member is securely fixed to said container of said power operating means.

6. The apparatus of claim **4,** wherein said free end of said piston is adjustably connected to said spider member.

7. The combination of claim **1,** wherein said mass of material sensitive to a limited range of temperatures is a wax which undergoes a solid-liquid transition in accordance with the temperature of the fluid.

8. The combination of claim **1** wherein said narrow range of temperatures to which said mass of material is sensitive to operate said valve to modulate the flow of said refrigerant fluid through said valve body is of the order of approximately 28°F. to 39°F.

9. The combination of claim **1** wherein said refrigerant fluid metering means includes a thermostatic expansion valve.

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