Jan. 23, 1951 | E. J. DILLMAN | 2,539,062

THERMOSTATIC EXPANSION VALVE

Filed April 5, 1945

FIG. 1

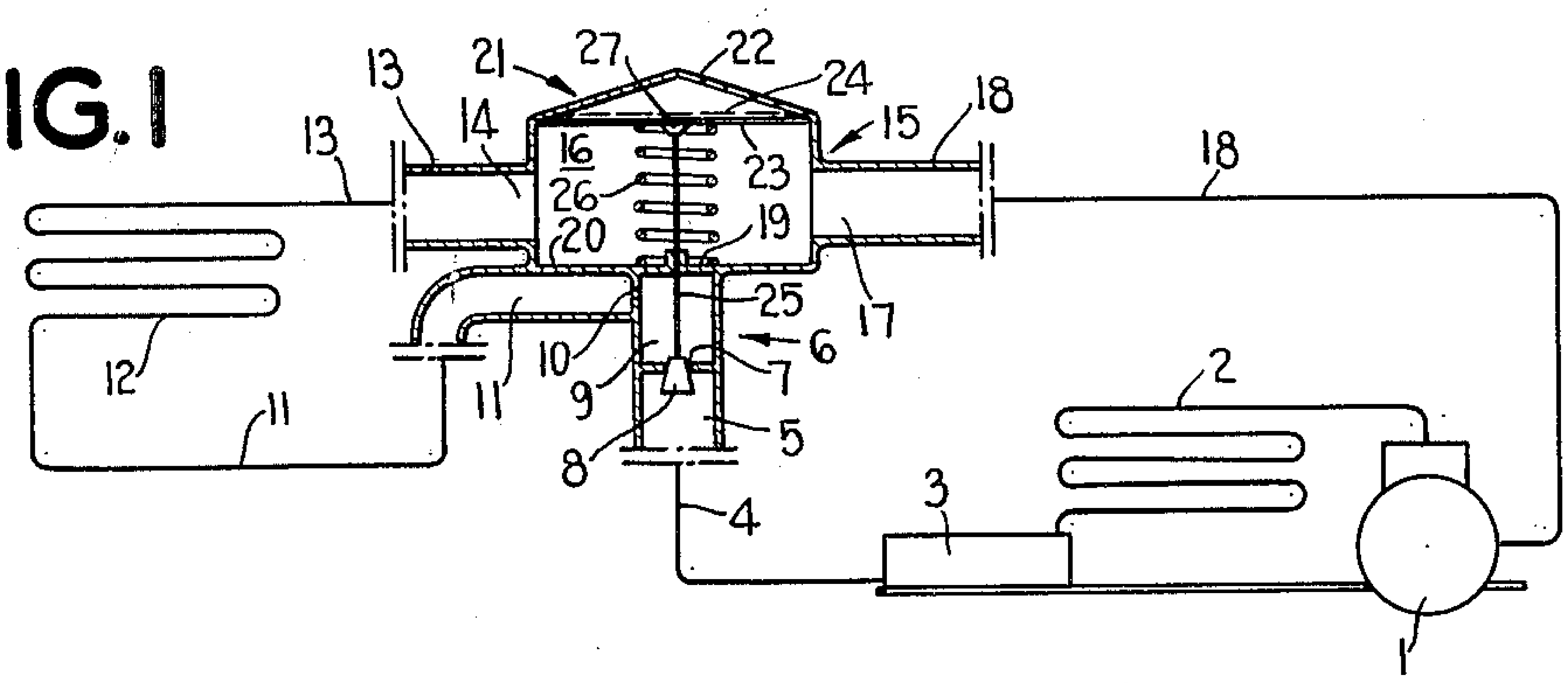


FIG. 2

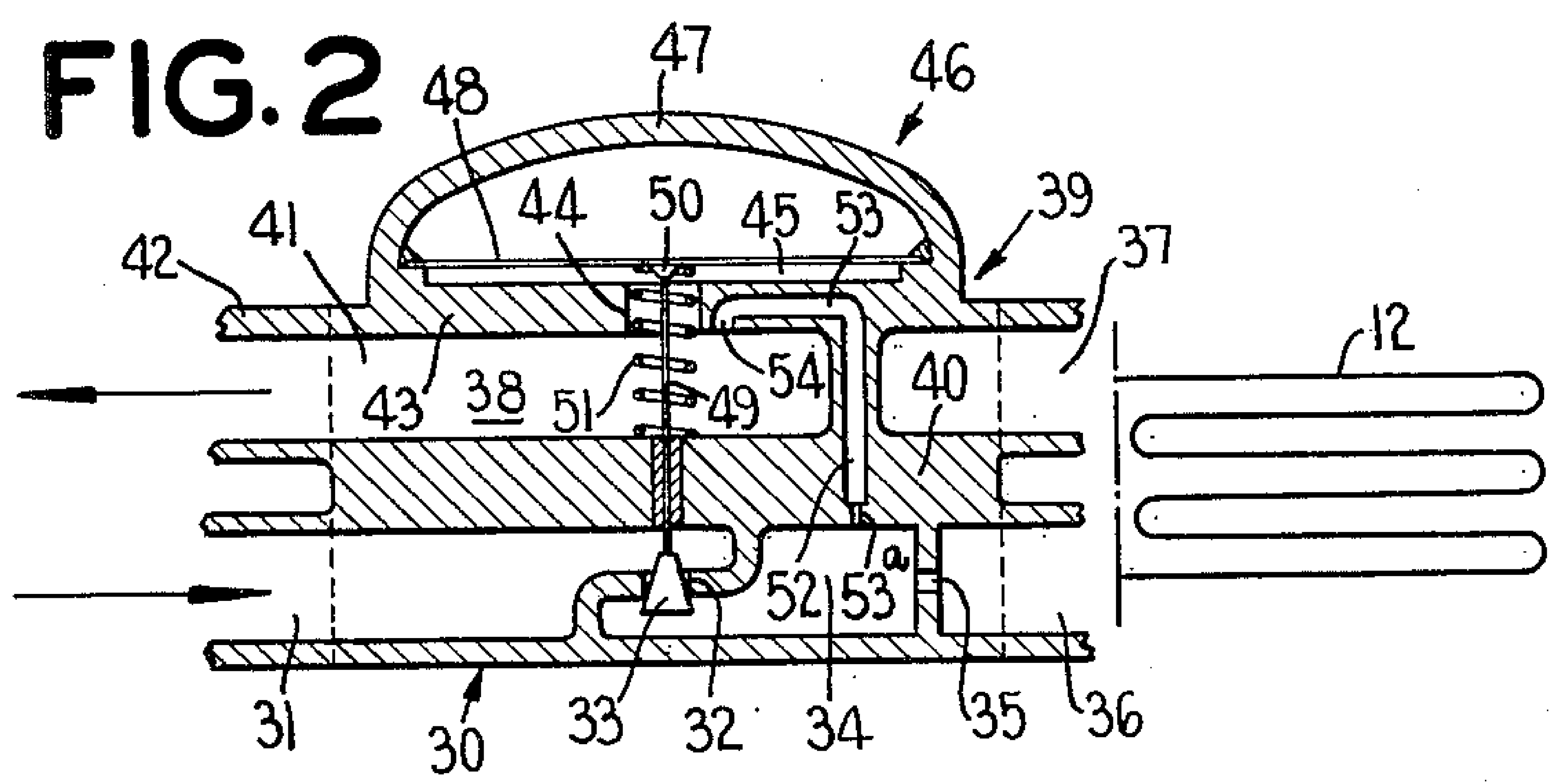


FIG. 6

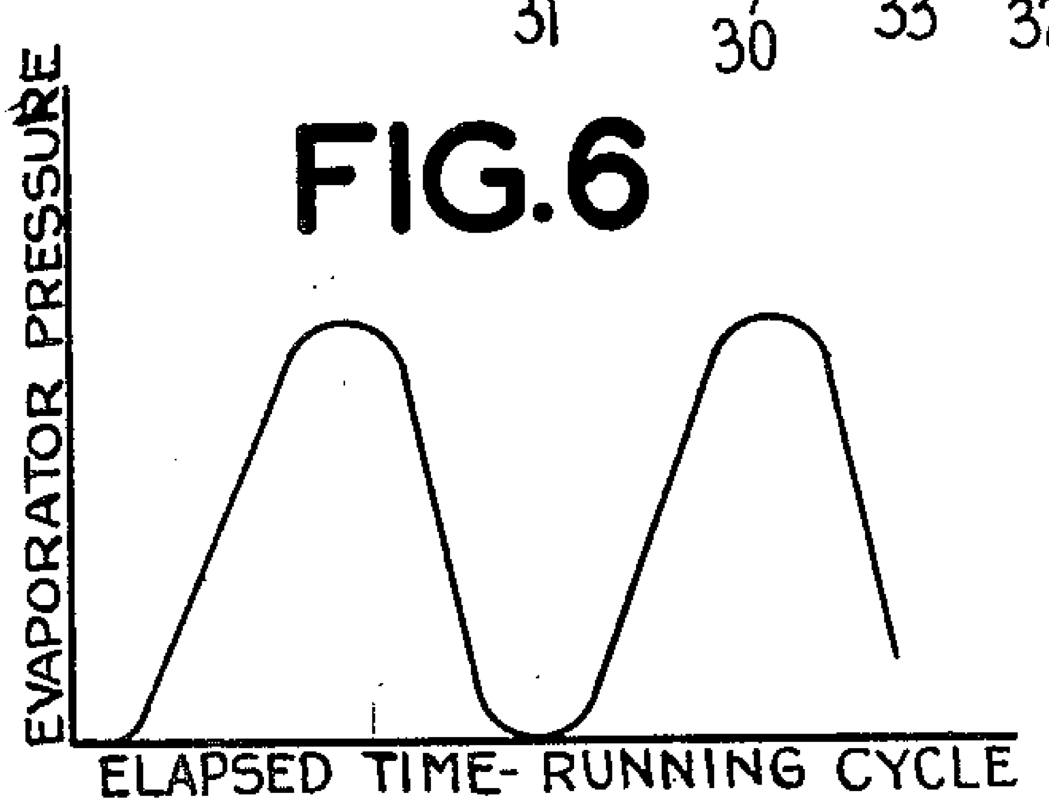
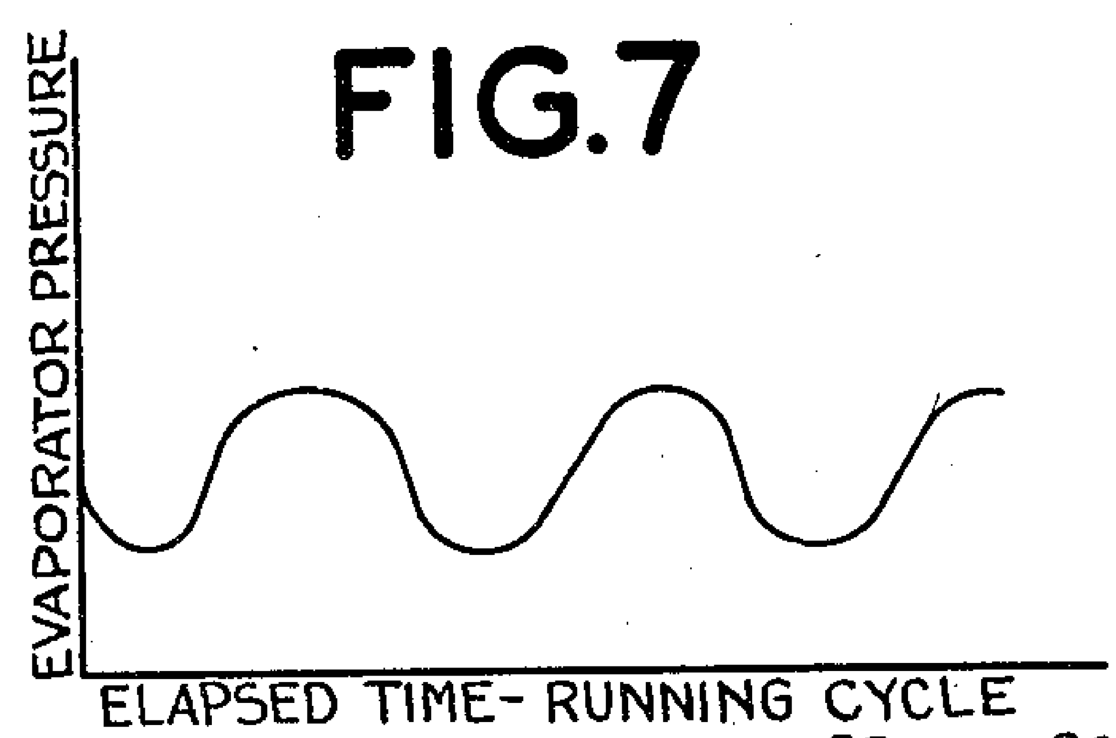


FIG. 7



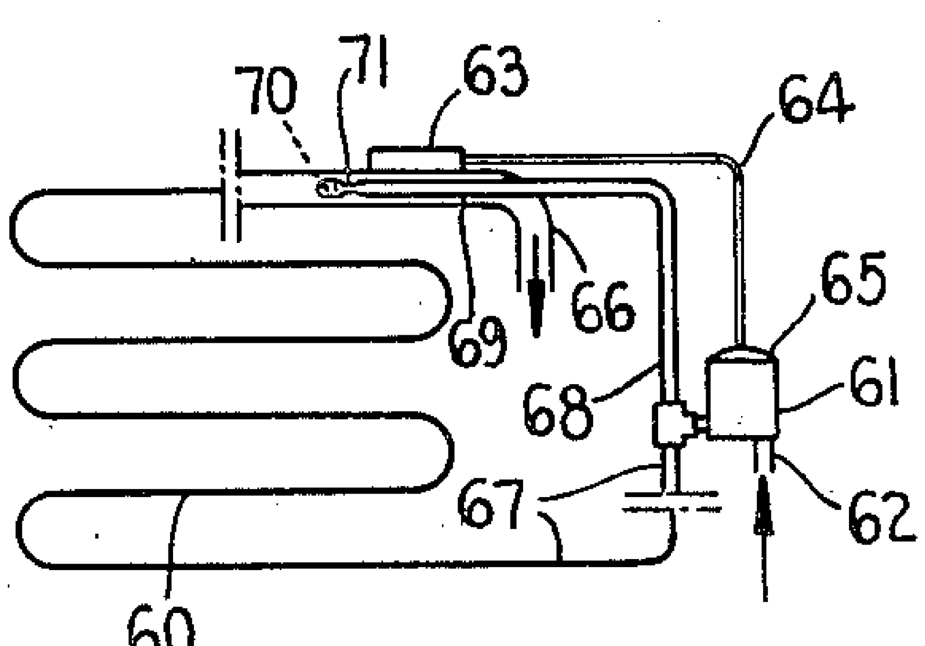
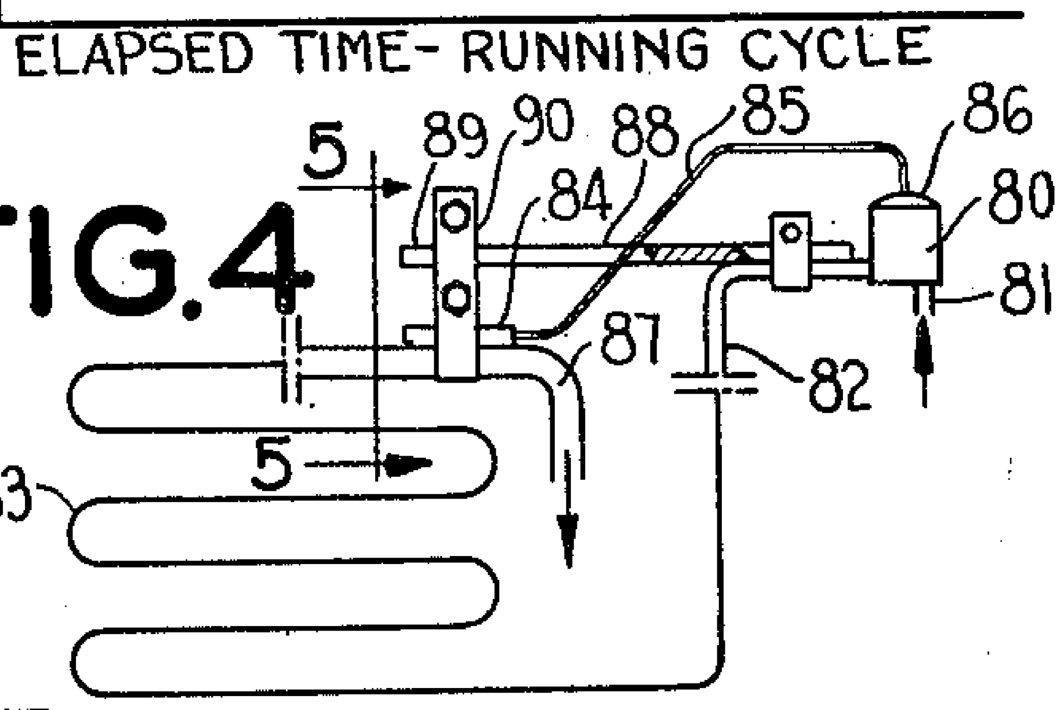


FIG. 3

FIG. 4



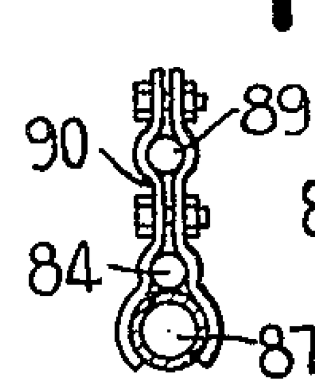


FIG. 5

INVENTOR.
Earnest J. Dillman

BY
Andrew K. Foulds
his ATTORNEY

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THERMOSTATIC EXPANSION VALVE

Earnest J. Dillman, Detroit, Mich., assignor to Detroit Lubricator Company, Detroit, Mich., a corporation of Michigan

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10 Claims. (Cl. 62—8)

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This invention relates to new and useful improvements in mechanical refrigeration systems and more particularly to the control of a thermostatic expansion valve for regulating the supply of refrigerant medium to the evaporator.

In thermostatic expansion valves, the temperature responsive element which controls the operation of the valve member responds to the temperature of the refrigerant vapor leaving the evaporator and accordingly, the valve admits a greater quantity of refrigerant medium to the evaporator than is desirable. Therefore the refrigerant medium will flood over into the suction line and there will be surging in the system. This has the disadvantage that the evaporator operates inefficiently since the evaporator will be starved in recurring cycles during compressor operation.

It is therefore one object of my invention to provide a valve which will anticipate the filling of the evaporator with refrigerant medium thereby eliminating or materially reducing the surging effect.

Another object is to provide means to close the valve immediately upon its feeding of refrigerant medium when the valve is opened by the temperature responsive power element during the off cycle or period when the compressor is not running.

The invention consists in the novel cooperative relation and arrangement of parts to be more fully described hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawing, to be taken as a part of this specification, there are fully and clearly shown several preferred embodiments of the invention, in which drawings:

Figure 1 is a diagrammatic view of a refrigeration system showing diagrammatically a suction line type thermostatic valve in section and operatively arranged in the system.

Fig. 2 is a diagrammatic view of another form of a suction line type thermostatic valve in section and operatively connected to an evaporator as in Fig. 1.

Fig. 3 is a diagrammatic view of a part of a refrigeration system showing a thermostatic expansion valve of the feeler bulb type operatively connected to an evaporator with means for anticipating flooding of the evaporator.

Fig. 4 is a view similar to Fig. 3 but showing another form of means for anticipating flooding of the evaporator.

Fig. 5 is a detail view in section on the line 5—5 of Fig. 4.

Fig. 6 is a chart showing the surging of evaporator pressure which occurs with valves of the prior art, and

Fig. 7 is a chart showing the reduction in the surging of the evaporator pressure with this invention.

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Referring to Fig. 1 by characters of reference, 1 designates generally a motor driven compressor discharging thru a pipe or conduit into a condenser 2 which feeds into the usual tank or receiver 3 from which the refrigerant liquid line 4 connects to the inlet 5 of the thermostatic expansion valve 6 of this invention. In the casing of the valve 6 there is a valve port 7 controlled by a valve member 8 and discharging into a valve outlet chamber 9 from which an outlet port 10 leads into an outlet conduit 11 which connects to the inlet of an evaporator 12. The outlet of the evaporator is connected by the usual suction line or return line 13 to the inlet 14 of a suction line casing 15 containing a refrigerant pressure chamber 16. The outlet 17 from the chamber 16 is connected by a suction line or return line conduit 18 to the inlet of the compressor 1. The end wall 19 of the casing 15 forms the end wall of the valve outlet chamber 9 so that the casing 15 and the casing of the valve 6 are in direct heat exchange relation. The conduit 11 also has its wall common to the suction line casing wall 19 as at 20. Opposite the wall 19 the casing 15 is closed by a temperature responsive power element 21 in the form of a capsule having a rigid cover member or cap 22 in direct heat exchange relation with the side wall of the suction line casing and having a movable wall or diaphragm 23 responsive to pressure changes in the chamber 16. The power element 21 is charged with a minute quantity of volatile liquid 24 such that the liquid will all be in vapor state at a temperature in the chamber 16 above the operating temperature range of the valve. The diaphragm 23 responds to changes of pressure in accordance with the temperature of the liquid 24. The valve member 8 is operatively connected to the diaphragm 23 by an operating member or thrust rod 25 preferably a flexible resilient wire which extends with a sliding fit through an aperture in the wall 19 thereby to eliminate leakage from the chamber 9 into the chamber 16. Expansion of the capsule and movement of the diaphragm 23 by pressure within the element 21 is opposed by a spring 26 which acts against the diaphragm 23 and normally urges the valve member 8 toward its seat and port closing position by reason of the connection of the rod 25 to the diaphragm 23 as at 27.

The operation of this valve of Fig. 1 is as follows: When the compressor 1 is started in operation and creates a reduction of pressure in the chamber 16, the valve member 8 will be opened by the diaphragm 23 and rod 25. Liquid refrigerant medium will discharge through the port 7 into the valve outlet chamber 9 and outlet conduit 11 vaporizing therein to cool the wall 19 and the wall portion 20 so as to abstract heat from the power element 21. This will cause some of the vapor in the power element 21 to condense so that the spring 26 will throttle the valve member 8 and move it toward port closing position thereby reducing the rate of supply of refrigerant medium to the evaporator 12. Accordingly, the valve will anticipate the reduction in temperature of the superheated refrigerant vapor drawn through the chamber 16 by the compressor. Since the valve member 8 has been moved closer to its seat by this auxiliary extraction of heat from the power element 21, the element 21 will, in its subsequent operation maintain the evaporator refrigerated to a more uniform extent. When the compressor 1 is stopped, the back pressure in the suction line in conjunction with the spring 26 in the chamber 16 acting on the diaphragm 23 will hold the valve member 8 closed, but if the temperature surrounding the power element 21 increases the pressure within the capsule sufficiently to move the valve member 8 to open position, then refrigerated medium admitted to the chamber 9 and vaporizing therein will cool the wall 19 sufficiently to abstract the necessary heat from the power element 21 to condense the vapor therein and seat the valve member 8. It will, of course, be apparent that if the abstraction of heat by the wall 19 is insufficient to cause closing of the valve member 8 that vaporization of refrigerant medium supplied by the still open valve port will refrigerate the wall portion 20 and this further abstraction of heat from the power element 21 will close the valve member 8. This action of the valve 6 during the off cycle of the compressor 1 will maintain the liquid refrigerant in the receiver 3 with very little loss during periods when the ambient temperature might cause the power element 21 to open the valve member 8.

Referring to Fig. 2, the suction line type thermostatic expansion valve has a valve casing 30 with an inlet 31 for connection to the liquid line 4 of the system of Fig. 1. The casing 30 has a valve port 32 controlled by a valve member 33 and discharging into an outlet chamber 34 having an outlet port 35 discharging into an outlet conduit 36 for connection as in Fig. 1 to the evaporator 12. The outlet of the evaporator 12 connects by a suction line conduit 37 to the pressure chamber 38 of a suction line casing 39. The chamber 38 has a wall 40 common to the wall of the valve outlet chamber 34 and the outlet conduit 36 and has an outlet port 41 for connection by a return or suction line or conduit 42 to the inlet of the compressor. The chamber 38 has a wall 43 with a pressure conveying port 44 therethrough which opens into a pressure chamber 45. A temperature responsive power element 46 in the form of a capsule having a cap or cover member 47 and a diaphragm 48 closes and seals the chamber 45 and accordingly the chamber 38. The capsule or power element 46 is charge with a minute quantity of volatile liquid such that the liquid will all be in vapor state above the operating temperature range of the valve. The cap 47 is connected to and in direct heat exchange relation to the casing 39. The diaphragm 48 is movable in accordance with temperature changes in the element 46 and with pressure changes in the chamber 38. The valve member 33 is operatively connected to the diaphragm 48 by an operating member 49 which is connected as at 50 to the diaphragm and extends through the port 44 and through an aperture in the wall 40 in which it has a sliding fit to prevent flow of refrigerant medium from the valve inlet 31 to the chamber 38. Expansion of the diaphragm 48 to open the valve member 33 is opposed by a coil spring 51. Leading from the outlet chamber 34 there is a conduit 52 having a conduit portion 53 extending through the suction line casing wall 43 in close proximity to the diaphragm 48 and in heat exchange relation to the power element 46. The conduit 52 has a bleed port or orifice 53a at its inlet end and has its outlet end discharging as at 54 into the chamber 38.

The operation of the valve of Fig. 2 is as follows: When the compressor is started in operation, the reduction of pressure in the chamber 45 will cause the diaphragm 48 to open the valve member 33 so that refrigerant medium will flow into the valve outlet 34 and the valve outlet conduit 36 for discharge into the evaporator 12. The vaporization of the refrigerant medium in the outlet chamber 34 and outlet conduit 36 will cool the wall 40 thereby abstracting heat from the power element 46. In addition there will be cooling of the power element 46 by refrigerant medium flowing through the conduit 52 in by-passing relation to the evaporator 12. The heat abstracted from the power element 46 by the expanding or vaporizing of refrigerant medium in the conduit portion 53 together with the heat abstracted by the cooled wall 40 will condense some of the vapor of the volatile liquid in the power element 46 so that the spring 51 will throttle or move the valve member 33 toward port closing position. Accordingly, the rate of supply of refrigerant to the evaporator 12 will be reduced so that the evaporator will not flood over into the suction chamber 38. Since the conduit 52 leads from the outlet chamber 34 on the inlet side of the port 35, the supply of refrigerant medium to the conduit portion 53 will be in accordance with the open position of the valve member 33. During the off cycle of operation of the compressor, opening of the valve member 33 by temperature of the air surrounding the power element 46 will result in closure of the valve member as above described in connection with Fig. 1.

Referring to Fig. 3, the supply of refrigerant to the evaporator 60 is by means of a thermostatic expansion valve 61 having an inlet 62 for connection to the refrigerant liquid line 4. This valve 61 may be any of the well known types of thermostatic expansion valve having a temperature responsive power element in which there is a feeler bulb or member 63 connected by a capillary tube 64 to an expansion chamber or capsule 65. The feeler bulb 63 is connected in heat exchange relation to the evaporator adjacent its outlet or to the suction or return line 66 from the evaporator. The outlet of the valve 61 is connected by a conduit 67 to the inlet of the evaporator 60. From the conduit 67 adjacent the expansion valve 61 a conduit 68 leads to the suction line 66 in by-passing relation to the evaporator 60. This conduit 68 may be in heat exchange relation to the suction line 66 adjacent the bulb element 63 as at 69 and is connected into the suction conduit 66 as at 70 closely adjacent but preferably on the evaporator side of the bulb element 63 so that refrigerant medium discharging into the suction line 66 from the conduit 68 will pass in heat exchange relation to the bulb element 63. The conduit 68 preferably has a restricted or calibrated port 71 adjacent its outlet end at the suction line to limit the flow of refrigerant medium therethrough.

The operation of a refrigeration system constructed as in Fig. 3 is as follows: As soon as the valve 61 opens upon operation of the compressor, some refrigerant will flow directly through the conduit 68 into the suction line 66 in by passing relation to the evaporator 60. The refrigerant medium which vaporizes in the conduit 68 will cool the bulb element 63 by reason of the heat exchange contact as at 69 and together with the expanding refrigerant medium discharging into the suction line 66 at the connection 70 will cause some of the vapor in the bulb element 63 to condense thereby throttling the valve 61. Accordingly the cooling of the bulb element 63 by this by passing refrigerant medium in and from the conduit 68 will anticipate the flooding of the evaporator and reduce the rate of supply of refrigerant medium through the conduit 67 to the evaporator.

In Fig. 4, the thermostatic expansion valve 80 has an inlet 81 for connection to the liquid line 4 and has an outlet conduit 82 which connects to the inlet of the evaporator 83. The valve 80 like the valve 61 has a temperature responsive power element with a bulb element or feeler member 84 connected by a capillary tube 85 to the expansion chamber or capsule 86. This bulb element 84 is clamped to the evaporator adjacent its outlet or to the suction or return line or conduit 87 which connects to the inlet of the ocmpressor. Secured in heat exchange relation to the casing of the valve 80 and preferably clamped to the outlet conduit 82 adjacent the valve there is a heat conducting rod or solid metal member 88 which at its free end portion 89 is connected in heat exchange relation to the bulb element 84. The rod end portion 89 is clamped to the bulb element 84 and the bulb element 84 is clamped to the suction line 87 by a metal heat conducting clamp 90.

The operation of the valve arrangement of Figs. 4 and 5 is as follows: When the valve 80 opens to supply refrigerant medium through the conduit 82 to the evaporator 83, rod 88 will be cooled at its connection to the valve and thereby due to its heat conducting relation to the bulb element 84, will abstract heat from the bulb element and cause some of the vapor of the volatile liquid in the bulb element 84 to condense. This will result as in the valve arrangement of Figs. 1, 2 and 3 in a throttling of the valve 80 and a reduction in the rate of refrigerant medium supplied to the evaporator 83. Accordingly, as above described with respect to the foregoing valves, the surging and inefficient operation of the evaporators will be materially reduced.

In the charts of Figs. 6 and 7, the curves show relative to each other the surging in Fig. 6 which usually occurs with prior art valves since the temperature responsive power element has no control of the valve until the evaporator is substantially flooded to the power element. In Fig. 7 the curve illustrates how the abstraction of heat from the temperature responsive power element occurring substantially immediately upon opening of the valve reduces the surging in the evaporator and thereby maintains a much more uniform length or average length of the evaporator in operation during the running of the compressor.

What is claimed and is desired to be secured by Letters Patent of the United States is:

1. In a thermostatic expansion valve, a suction line casing having an inlet and an outlet for flow of vaporized refrigerant therethrough, temperature responsive valve operating means in heat exchange relation with said casing, a valve casing having an outlet port and in heat exchange relation with said suction line casing so that refrigerant flowing through said valve casing will abstract heat from said operating means, and a conduit leading from said outlet port and extending from said valve casing in heat exchange relation with said operating means for increasing the abstraction of heat from said operating means.

2. In a thermostatic expansion valve, a suction line casing having an inlet and an outlet for flow of vaporized refrigerant therethrough, temperature responsive valve operating means in heat exchange relation with said casing, a valve casing in heat exchange relation with said suction line casing so that refrigerant flowing through said valve casing will abstract heat from said operating means, and a conduit leading from said valve casing in direct contact with said suction line casing for increasing the abstraction of heat from said operating means.

3. In a thermostatic expansion valve, a suction line casing having an inlet and an outlet for flow of vaporized refrigerant therethrough, a cap member and diaphragm forming an expansible chamber valve operating means, volatile liquid in said means, said cap member being in heat exchange relation with said casing, said diaphragm being exposed to and responding to pressure changes in said casing, a valve casing in heat exchange relation with said suction line casing so that refrigerant flowing through said valve casing will abstract heat from said operating means, and means for increasing the abstraction of heat from said operating means.

4. A thermostatic expansion valve comprising a valve casing having an inlet and having an outlet chamber, a suction line casing having a pressure chamber, said chambers having a common wall, a temperature responsive capsule in heat exchange relation with said wall and having a diaphragm closing a wall opening of said suction line casing, a minute quantity of volatile liquid in said capsule such that all of the liquid will be in vapor state at a temperature in said suction line casing above the operating temperature range of the valve, a valve member controlling refrigerant flow into said outlet chamber and operatively connected to said diaphragm, vaporization of refrigerant in said outlet chamber chilling said common wall upon opening of said valve member thereby to condense some of the vapor in said capsule and reduce the pressure therein to close said valve member.

5. A thermostatic expansion valve comprising a suction line casing having a wall opening and having an inlet and an outlet for flow of vaporized refrigerant through said casing, a temperature responsive capsule in heat exchange relation with said casing and having a diaphragm closing said wall opening of said suction line casing, volatile liquid in said capsule, a valve casing secured to said suction line casing, a valve member controlling flow through said valve casing,

means for transmitting movement from said diaphragm to said valve member, and a conduit having heat exchange relation intermediate its ends with said capsule and extending from the outlet side of said valve casing and discharging into said suction line casing.

6. A thermostatic expansion valve comprising a suction line casing having a wall opening and having an inlet and an outlet for flow of vaporized refrigerant through said casing, a temperature responsive capsule in heat exchange relation with said casing and having a diaphragm closing said wall opening of said suction line casing, volatile liquid in said capsule, a valve casing secured to said suction line casing, a valve member controlling flow through said valve casing, means for transmitting movement from said diaphragm to said valve member, and a conduit leading from the outlet chamber of said valve casing and discharging into said suction line casing, said conduit having a restriction and having a portion of its length in contact with said suction line casing adjacent said diaphragm.

7. A refrigerant controlling apparatus of the character described, comprising in combination, a valve casing having a wall, a valve member in and controlling flow through said casing, temperature responsive means positioned external of said casing wall and including means operable upon reduction of temperature to move said valve member toward closed position, means to conduct refrigerant medium in heat exchange relation to said responsive means, means operatively connecting said responsive means to said valve member and operable to transmit movement therebetween; auxiliary means operable to abstract heat from said temperature responsive means in anticipation of temperature reduction of said responsive means by said refrigerant conducting means, and said auxiliary means being controlled solely by said valve member and having its temperature reducing action varied in accordance with the position of said valve member.

8. A refrigerant controlling apparatus as defined in claim 7 wherein the temperature responsive means is a volatile fluid expansive power element having an external feeler bulb, and the auxiliary temperature abstracting means being arranged to act upon said feeler bulb.

9. A refrigerant controlling apparatus as defined in claim 7 wherein the temperature responsive means is a volatile fluid expansive power element having an external feeler bulb, and said auxiliary heat abstracting means comprising a conduit controlled solely by said valve member and discharging expanding refrigerant in heat exchange relation with said feeler bulb.

10. A refrigerant controlling apparatus as defined in claim 7 wherein the temperature responsive means is a volatile fluid expansive power element having an external feeler bulb, and said auxiliary heat abstracting means comprising a heat conducting member connected to said feeler bulb and to said casing for transfer of heat therebetween upon opening said valve member.

EARNEST J. DILLMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
971,788	Pollard	Oct. 4, 1910
1,719,074	Muffly	July 2, 1929
1,719,075	Muffly	July 2, 1929
1,813,168	Kalischer	July 7, 1931
2,280,425	Sanders	Apr. 21, 1942
2,353,240	Huggins	July 11, 1944

FOREIGN PATENTS

Number	Country	Date
324,957	Great Britain	Feb. 7, 1930
335,208	Great Britain	Sept. 19, 1930