May 20, 1941. D. D. WILE 2,242,334

REFRIGERATING SYSTEM

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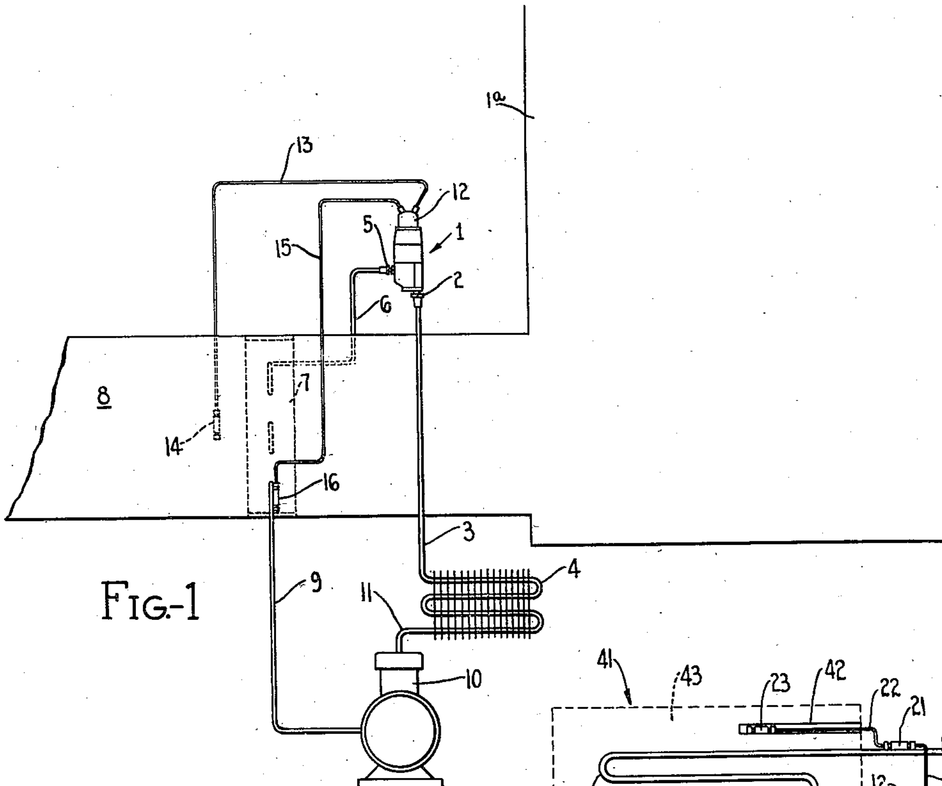

FIG-1

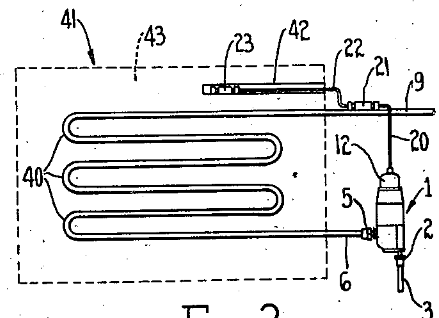

FIG-3

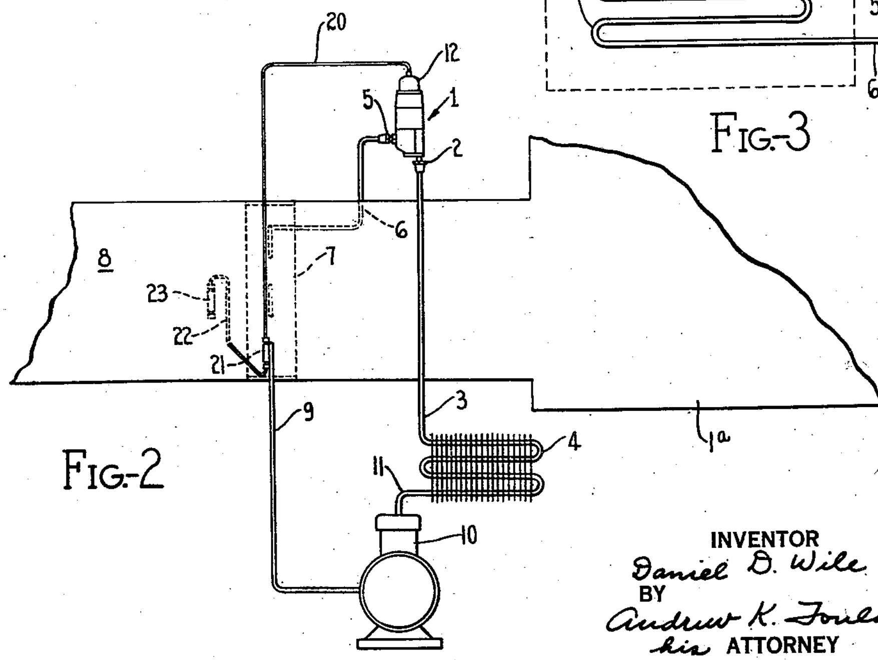

FIG-2

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REFRIGERATING SYSTEM

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14 Claims. (Cl. 62—2)

My invention relates generally to refrigerating systems and more particularly to those using a thermostatic expansion valve.

An object of my invention is to provide means for controlling the flow of a refrigerating medium in a refrigerating system to prevent more than a predetermined maximum supply of refrigerant in the evaporator.

A further object is to provide means for closing the valve to flow of refrigerant in the event that the medium surrounding the evaporator becomes colder than the temperature of the suction line controlling means.

Another object is to prevent operation of the refrigerating equipment when the medium surrounding the evaporator is sufficiently cool and requires no cooling.

Another object is to prevent excessive flooding back of the refrigerant upon starting up of the refrigerating mechanism.

Another object is to furnish means to alleviate the difficulties caused by the warming of the flow controlling responsive means relative to the evaporator.

The invention consists in the improved construction and combination 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, I have fully and clearly illustrated my invention, in which drawing—

Figure 1 shows a schematic illustration of a refrigerating system having an air cooling coil or evaporator within an air duct and embodying my invention;

Fig. 2 is a view similar to Fig. 1 but showing a different means for controlling the refrigerant medium flow, and

Fig. 3 shows schematically one form of my invention as used in connection with a brine tank cooler.

Referring to the drawing by characters of reference the numeral 1 designates generally a controlling means which in this case is shown as a thermostatic expansion valve having its inlet or liquid port 2 connected by means of a conduit 3 to a condenser 4. The outlet or low pressure side 5 of the expansion valve 1 is connected by means of a conduit 6 to an evaporator or low side element 7, preferably of the coil type and located within a cooling chamber which is an air duct 8 so that the air or controllable means which flows therethrough and discharges into the space or room 1a, i. e. flow from left to right facing Fig. 1, will be in heat exchange relation with the evaporator 7. The evaporator 7 has an outlet conduit or suction line 9 leading to a compressor 10 which is connected by means of a conduit 11 to the condenser 4 to form a complete refrigerating system, within which system the refrigerant or performing means is confined.

Leading from the power element 12 of the thermostatic expansion valve 1 there is a fluid pressure conveying conduit 13 having one end communicatively connected to the power element 12. The opposite end of the conduit 13, which is located within the air duct 8 adjacent the evaporator 7, has an actuating means or chambered feeler bulb 14 communicatively connected thereto. A second fluid pressure conveying conduit 15 has one end communicatively connected to the power element 12 and has at its opposite end an actuating means or chambered feeler bulb 16 operatively connected thereto. A sealed, closed, interconnected control system is thereby formed of the members 12 to 16 each inclusive, and is charged with a predetermined amount of a temperature sensitive, volatile fluid of a quantity and of such proportions that the entire fluid in a liquid state may be contained in either of the two feeler bulbs 14 or 16. This allows the fluid pressure in the control system to be controlled solely by the bulb which is at the lower temperature. The feeler bulb 14 is positioned within the air duct 8 with the tube 13 leading from its upper end, and is preferably in the untempered air stream, i. e. on the inlet side of evaporator 7, in good heat exchange relation with the air. The feeler bulb 16 is secured in good heat exchange relation to the outlet conduit 9 adjacent the evaporator 7 so that the bulb 16 will be accurately responsive to the temperature of the refrigerant adjacent the evaporator outlet, but the bulb is preferably external of the duct 8 so that it can be removed without extensive alterations to the duct.

In Fig. 2 parts defined with respect to Fig. 1 and similar thereto are designated by like numerals. Communicatively connected to the power element 12 there is one end of a fluid pressure conveying conduit 20 having its other end connected to one end of a feeler bulb 21. The feeler bulb 21 is secured in good heat exchange relation to the suction or return line 9 adjacent to the outlet of evaporator 7 but external of the air duct 8, within which duct the evaporator 7 is placed. Communicatively connected to the opposite end of the feeler bulb 21 is one end of a fluid pressure conveying conduit 22. The other or opposite end of the conduit 22 is communicatively connected to a feeler bulb 23 which is located in the inlet air stream to the evaporator 7 within the air duct 8. The members 12, 20, 21, 22 and 23 in this modification form a sealed control system which is charged with a temperature sensitive, volatile fluid in a manner similar to that of Fig. 1.

The parts heretofore defined in connection with Figs. 1 and 2 are designated by like numerals in Fig. 3. The outlet 5 of the thermostatic expansion valve 1 is connected by means of the conduit 6 to an expansion coil 40 located within a liquid receptacle, such as a brine tank or cooling chamber generally designated at 41. The outlet of the coil 40 is connected to the outlet conduit 9 which leads to the compressor 10, and the inlet 2 to valve 1 is connected to the condenser 4 by conduit 3, as in Figs. 1 and 2. The temperature responsive bulb 21, connected by conduit 20 to the expansion valve power element 12, is fastened to the suction line conduit 9 adjacent its outlet from tank 41 and in good heat exchange relation thereto. The bulb 23, in communication with bulb 21 by conduit 22, is inserted into the brine tank 41, as for example by means of a sealed tubular member or well 42, and is in good heat exchange relation with the liquid or brine 43 within the brine tank 41.

The operation of the apparatus of Fig. 1 is as follows: High pressure liquid refrigerant flows from the condenser 4 through the liquid line 3 and into the thermostatic expansion valve 1 by means of the inlet 2. The refrigerant is metered by the valve 1 and the metered refrigerant, which is substantially a liquid, leaves the valve through outlet 5 and passes through conduit 6 into the evaporators 7 where it is completely vaporized by the heat extracted from the air which flows through the air duct 8. The gaseous refrigerant then passes through the outlet or suction line conduit 9 to the compressor 10 which maintains a predetermined pressure in the suction line 9. The gaseous refrigerant is compressed by the compressor 10 to raise the temperature of the heat contained in the low pressure vapor, and the high pressure vapor is exhausted through conduit 11 into the condenser 4. Heat is dissipated by the condenser 4 to liquify the refrigerant.

The operation of the valve 1 will be controlled by the bulb 14 or the bulb 16, whichever has the lower temperature, and this is possible by predetermining the capacity of and the quantity of volatile liquid charge in the feeler bulb or control system such that all of the temperature sensitive or responsive fluid therein, which is in the liquid stage, may be at all times contained within one or the other of the feeler bulbs or elements. The pressure within the control system will be determined by the bulb having the lower temperature since there is no volatile liquid in the other bulb, and the bulb of lower temperature will assume control over the thermostatic expansion valve 1. The feeler bulb 16, located in heat exchange relation with the suction line 9, governs the quantity of refrigerant supplied by the expansion valve 1 to the evaporator 7 during the time that the condensing unit is running and the evaporator is cooling the air flowing through the duct 8. The quantity of refrigerant supplied is controlled in such a manner by the bulb 16 that no liquid refrigerant escapes through the suction line 9 to the compressor 10. When the air within the air duct 8 becomes colder than the temperature for which the evaporator is set to operate, and the compressor 10 is no longer operating, the bulb 16 will warm up above the temperature of the bulb 14 and the bulb 14 will therefore assume control and will close the expansion valve to further flow of refrigerant. The valve 1 in operation tends to maintain constant the relationship of the liquid refrigerant temperature in the evaporator to the temperature of the controlling bulb which is maintained slightly warmer than the refrigerant. When the air entering the evaporator 7 is as cold or colder than the temperature at which the evaporator is set to operate, the compressor 10 will not need to be run so as to cool the evaporator, thereby to cool the air passing through it. The bulb 16 which is located outside of the duct 8 and in a warmer place than bulb 14, will tend to warm up due to the temperature of the surrounding medium. The bulb 14 within the duct 8 will be maintained at the duct air temperature, and the liquid portion of the charge which was in bulb 16 will distill over to bulb 14 because of its lower temperature. The pressure in the control system will then be controlled by the temperature at this bulb 14. As the evaporator, and consequently the refrigerant therein, will be at the temperature of bulb 14, there will be no difference of temperature between the bulb 14 and the refrigerant so that the back pressure of the refrigerant will hold the valve closed to further flow of refrigerant. When the duct air temperature warms up, and the compressor is again started, then the vaporizing refrigerant will cool the evaporator below duct air temperature. The suction line 9 and bulb 16 will be cooled below duct air temperature by the flow of cool refrigerant vapor through the line 9 and the control will be transferred from bulb 14 to bulb 16 for normal operation.

The operation of the apparatus of Fig. 2 is substantially the same as that of Fig. 1, but the bulbs here designated 21 and 23 are arranged in series and have only one conduit leading to the power element 12 of the expansion valve 1 so that when bulb 21 is the warmer, it serves merely as a part of the pressure conveying conduit for bulb 23. The pressure in this control system is likewise controlled by whichever of the bulbs is at the lower temperature, and either may contain all of the fluid which is in the liquid phase at any one time. The construction of this control system eliminates separate pressure conveying tubes or conduits leading from the valve power element and consequently is less expensive and requires in the majority of cases less length of tubing and is more convenient in installation.

The operation of the apparatus of Fig. 3 is similar to that of Figs. 1 and 2 in that the flow of refrigerant through the expansion valve 1 is controlled by the bulb having the lower temperature. During the "off" period of the compressor, which controls the refrigerating effect of the air cooling system, the suction line 9 will tend to warm up more rapidly than the brine 43 and evaporator coil 40 within the brine tank 41, due to the larger mass of the brine. If the "off" period of the compressor is sufficiently long, the bulb 21 will become warmer than the bulb 23 and transfer the control of the expansion valve to the bulb 23 which will close-off the expansion valve to further flow of refrigerant and prevent the coil 40 from becoming filled with liquid refrigerant and flooding back to the compressor through the suction line 9 when the compressor again begins to operate.

From the foregoing it will be apparent that the nominal control of the expansion valve by the bulb responsive to suction line or evaporator outlet temperature, is deprived of its controlling function during such times as the warming up of this bulb would have a deleterious effect on the refrigerating system.

What I claim and desire to secure by Letters Patent of the United States is:

1. In a refrigerating system including a cooling chamber having a refrigerant evaporator with a refrigerant return line, a valve for controlling the supply of refrigerant to the evaporator, power means for actuating said valve, and a pair of temperature responsive elements communicatively connected to said power means, one of said elements being subject to the temperature of the refrigerant return line, the other of said elements being subject to temperature in the cooling chamber, said elements and said means being charged with a predetermined quantity of condensible temperature responsive fluid which is volumetrically condensible for complete reception in one or the other of said elements so that the element at the lower temperature will have exclusive control of said valve.

2. In a refrigerating system including a cooling chamber having a refrigerant evaporator with a refrigerant return line, a valve for controlling the supply of refrigerant to the evaporator, power means for actuating said valve, a temperature responsive element, and a second temperature responsive element, said first-named responsive element being communicatively connected through said second-named responsive element to said power means, one of said elements being subject to the temperature of the refrigerant return line adjacent the evaporator, the other of said elements being subject to temperature in the cooling chamber, said elements and said means being charged with a predetermined quantity of condensible temperature responsive fluid which is volumetrically condensible for complete reception in one or the other of said elements so that the element at the lower temperature will have exclusive control of said valve.

3. In a refrigerating system including a cooling chamber having a refrigerant evaporator with a refrigerant return line, a valve for controlling the supply of refrigerant to the evaporator, power means for actuating said valve, a temperature responsive element, conduit means connecting said responsive element to said power means, a second temperature responsive element, and a second conduit means connecting said second-named responsive element to said power means, one of said elements being subject to the temperature of the refrigerant return line, the other of said elements being subject to temperature in the cooling chamber, said elements and said means being charged with a predetermined quantity of condensible temperature responsive fluid which is volumetrically condensible for complete reception in one or the other of said elements so that the element at the lower temperature will have exclusive control of said valve.

4. In a refrigerating system including an air supply duct having a refrigerated air cooling coil with a refrigerant flow controlling means, power means operable to control said flow controlling means, conduit means connecting said controlling means to the cooling coil so that refrigerant can flow from said controlling means to the cooling means, an outlet conduit from the cooling means, temperature responsive means subject to the temperature of said outlet conduit, means connecting said responsive means and said power means in operative relation, temperature responsive means subject to the temperature of the air in the supply duct, conduit means connecting said second-named responsive means and said power means, said responsive means, said conduit means and said power means defining a closed system, and a condensible temperature responsive fluid in said system and in such proportions that said fluid in the liquid phase can be at all times contained in either of said responsive means so that the responsive means which is at the lower temperature will assume absolute control over said power means.

5. A cooling system comprising a cooling coil for a liquifiable refrigerant medium, means to supply refrigerant medium to said coil, a valve controlling admission of the refrigerant medium to said coil, temperature responsive means regulating the operation of said valve, and means operable solely when the temperature of a medium to be cooled by said coil is below the temperature of said temperature responsive means to deprive said responsive means of any effect to influence the operation of said valve.

6. A cooling system comprising a cooling coil for a liquifiable refrigerant medium, means to supply refrigerant medium to said coil, a valve controlling admission of the refrigerant medium to said coil, an outlet conduit leading from said coil, temperature responsive means acting in accordance with the temperature of the refrigerant medium in said conduit and regulating the operation of said valve, and automatically acting temperature responsive means operable solely when the temperature of a medium to be cooled by said coil is below the temperature of said temperature responsive means to deprive said responsive means of any effect to influence the operation of said valve.

7. A cooling system comprising a cooling coil for a liquifiable refrigerant medium, means to supply refrigerant medium to said coil, a valve controlling admission of the refrigerant medium to said coil, temperature responsive volatile liquid containing means regulating the operation of said valve, and a chambered element communicating with and having a volumetric capacity sufficient to receive the liquid in said responsive means so that said responsive means is deprived of control of said valve when the temperature of a medium to be cooled by said coil is below the temperature of said temperature responsive means.

8. A cooling system comprising a cooling coil for a liquifiable refrigerant medium, means to supply refrigerant medium to said coil, a valve controlling admission of the refrigerant medium to said coil, temperature responsive means regulating said valve thereby to control the admission of refrigerant to said coil, and means operable solely when the temperature of a medium to be cooled by said coil is below the temperature of said temperature responsive means to deprive said responsive means of any effect to influence the admission of refrigerant to said coil.

9. A cooling system comprising a cooling coil for a liquifiable refrigerant medium, means to supply refrigerant medium to said coil, a valve controlling admission of the refrigerant medium to said coil, temperature responsive volatile liquid containing means regulating the operation of said coil, and a chambered element communicating with and having a volumetric capacity suffi-

cient to receive the liquid in said responsive means so that said responsive means is deprived of control of said valve when the temperature of a medium to be cooled by said coil is below the temperature of said temperature responsive means.

10. In a refrigerating system including a cooling chamber having a refrigerant evaporator with a refrigerant return line, a valve for controlling the supply of refrigerant to the evaporator, power means for controlling said valve thereby to regulate the admission of refrigerant to the evaporator, a temperature responsive element, and a second temperature responsive element, said first-named responsive element being communicatively connected with said second-named responsive element and operable to control said power means, one of said elements being subject to the temperature of the refrigerant in the return line, the other of said elements being subject to temperature in the cooling chamber, said elements and said means being charged with a predetermined quantity of condensible temperature responsive fluid which is volumetrically condensible for complete reception in one or the other of said elements so that the element at the lower temperature will have exclusive control of said valve.

11. In a refrigerating system for an enclosed space having duct means for supplying air thereto, evaporating means within the duct means and positioned in the air stream, means to convey refrigerant to said evaporating means, means for conveying the refrigerant from said evaporating means, a refrigerant controlling means in said first-named conveying means to control the flow of the refrigerant to said evaporating means, temperature responsive means secured to and responsive to the temperature of said second-named conveying means, and a second temperature responsive means responsive to the temperature of the air in the duct means, said first-named and said second-named responsive means being so interrelated that when said second-named responsive means is at a lower temperature than said first-named means said second-named responsive means will assume complete control of said controlling means to prevent excess refrigerant from entering said evaporating means.

12. In a refrigerating system for an enclosed space having duct means for supplying air thereto, evaporating means within the duct means and positioned in and transversely to the air stream, means to convey refrigerant to said evaporating means, means for conveying the refrigerant from said evaporating means, a refrigerant controlling means in said first-named conveying means to control the flow of the refrigerant to said evaporating means, temperature responsive means secured to and responsive to the temperature of said second-named conveying means, and a second temperature responsive means positioned within the duct means and responsive to the temperature of the inlet air to said evaporating means, said first-named and said second-named responsive means being so interrelated that when said second-named responsive means is at a lower temperature than said first-named means said second-named responsive mean will asume complete control of said controlling means to prevent excess refrigerant from entering said evaporating means.

13. In a refrigerating system, an air supplying duct having an inlet and an outlet, evaporating means in said duct intermediate said inlet and said outlet, and a thermostatically operated valve comprising a first and a second temperature sensitive element, a power element and conduit means interconnecting said elements to form a sealed system, said valve being positioned external of said duct and operatively connected to said evaporating means and operable to control the flow of refrigerant to said evaporating means, said evaporating means having an outlet conduit means for conveying the refrigerant therefrom, said conduit means having a portion external of said duct, said first temperature sensitive element being secured to and in heat exchange relation with said portion, said second temperature sensitive element being positioned within said duct and sensitive to the temperature of the air therein, said valve being so constructed and arranged as to be operable to control flow of refrigerant in accordance with the fluid pressure in said system, said system containing an expansible temperature responsive fluid in such proportions relative to the volumetric capacity of said system that the quantity of fluid which is in liquid phase can at all times be contained in either of said sensitive elements so that the sensitive element which is at the lower temperature will assume control of the pressure in said system.

14. In a heat transfer apparatus utilizing a heat transfer fluid for modifying the temperature of an air stream which is supplied to a tempered space, a controlling means for regulating the flow of the transfer fluid, an actuating means responsive to the temperature of the transfer fluid and operable to control said controlling means, an actuating means responsive to the temperature of the air stream and operable to control said controlling means, conduit means connecting said first-named actuating means said second-named actuating means and said controlling means into an interconnected system, said system containing a volatile temperature responsive fluid in such proportions relative to the volumetric capacity of said system that the quantity of fluid which is in the liquid phase can at all times be contained in either of said actuating means so that the one of said actuating means which is at the lower temperature will assume control over said controlling means.

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