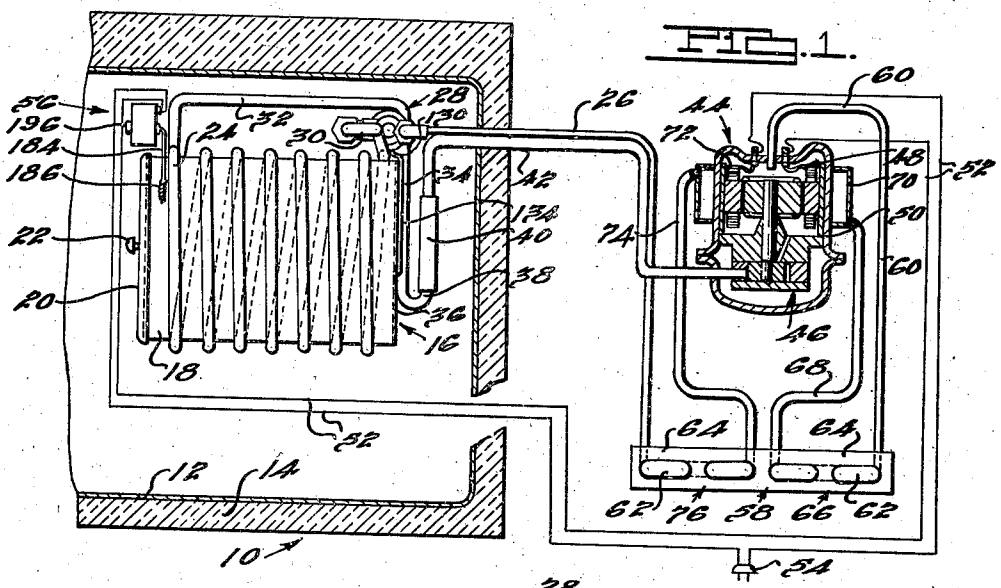
Aug. 12, 1941. E. F. HUBACKER 2,252,567

ART OF REFRIGERATION

Filed March 14, 1938 2 Sheets-Sheet 1

FIG. 1.



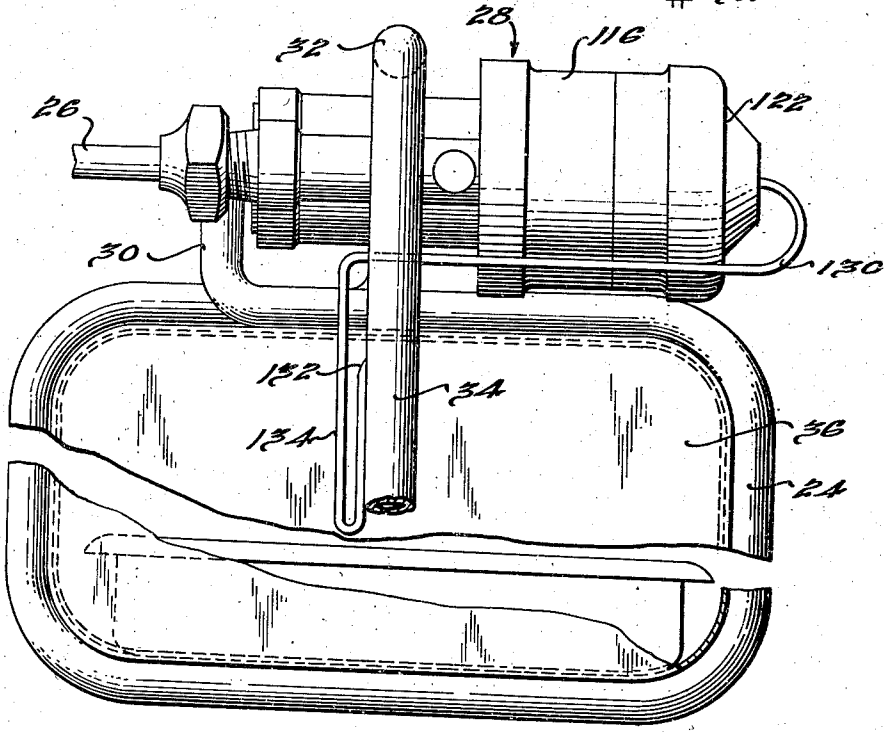


FIG. 2.

INVENTOR
Earl F. Hubacker.
BY
ATTORNEY

Aug. 12, 1941. E. F. HUBACKER 2,252,567

ART OF REFRIGERATION

Filed March 14, 1938 2 Sheets-Sheet 2

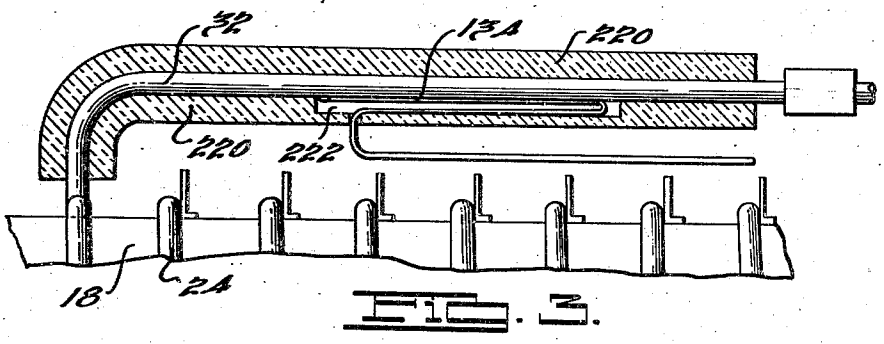


FIG. 3.

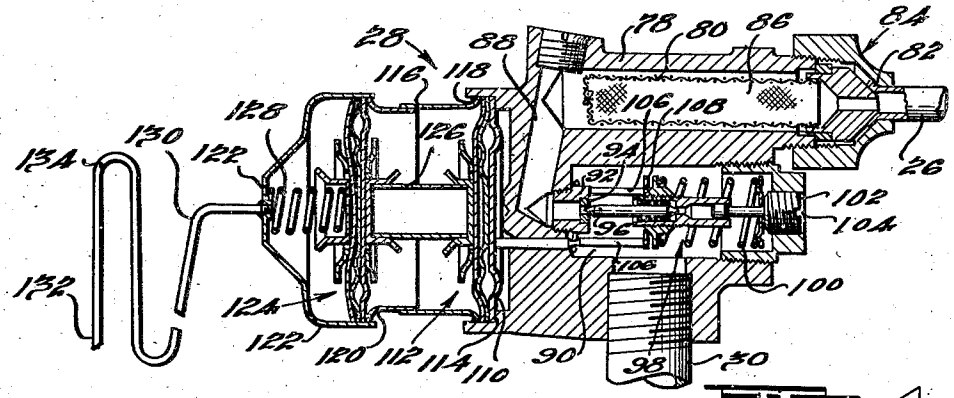


FIG. 4.

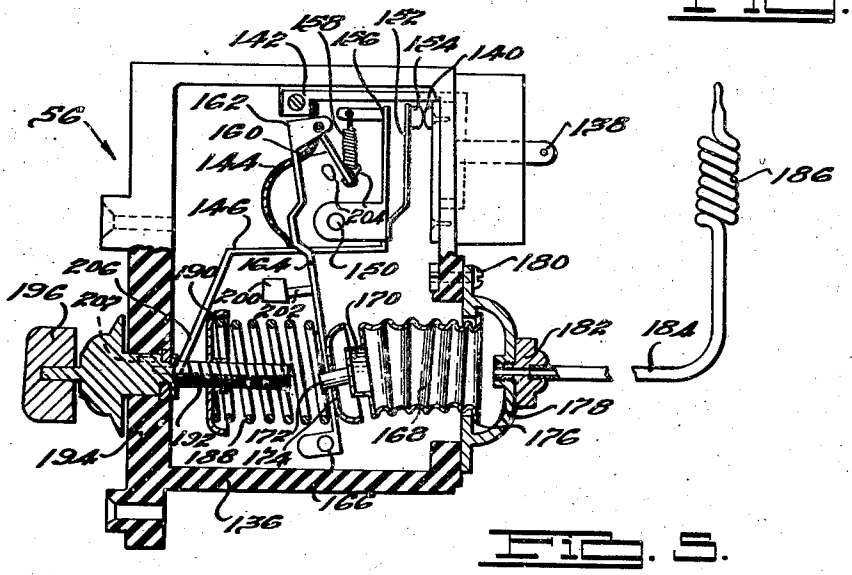


FIG. 5.

INVENTOR
Earl F. Hubacker.
BY
ATTORNEY

Patented Aug. 12, 1941 2,252,567

UNITED STATES PATENT OFFICE

2,252,567

ART OF REFRIGERATION

Earl F. Hubacker, Highland Park, Mich., assignor to Borg-Warner Corporation, Chicago, Ill,. a corporation of Illinois

Application March 14, 1938, Serial No. 195,815

8 Claims. (Cl. 62—8)

This invention relates to the art of refrigeration and more particularly that type of refrigeration which is suited for domestic installation.

In household refrigeration units one of the greatest problems which has been presented has involved the method or means which is employed for controlling the flow of refrigerant in a liquid state into the evaporator. A great many expedients have been resorted to for metering this flow of liquid refrigerant among which have been restricted openings which will permit only measured small quantities of refrigerant to flow into the evaporator, expansion valves which depend for their operation upon temperature and pressure conditions existing in the refrigerating compartment or in a portion of the suction line, or float devices of various types such as, for example, a float used on the high pressure side of the system, or a float used on the low pressure side of the system.

With the possible exception of the float devices, all of these expedients have been more or less unsatisfactory in that they permit quantities of liquid refrigerant to pass to the evaporator where it will fill the evaporator during the off-cycle of the machine, resulting in slugs of liquid refrigerant being drawn off from the evaporator through the suction line upon the initiation of the on-cycle of the machine, thus impairing the efficiency and greatly increasing the load upon the compressor and motor during starting.

While float devices of one kind or another have been successfully used to overcome these difficulties, such devices have been found to be relatively expensive, their manufacture necessitating a series of operations which require the exercise of a considerable amount of precaution in order to assure that they will operate properly. Because of this high cost and the delicacy of their construction, float devices have not been favorably regarded although they do cure to some extent the above-described deficiencies.

A cure for this situation lies in providing some means whereby the flow of liquid refrigerant to the evaporator is definitely stopped during the off-cycle of the machine in order to prevent the accumulation of liquid unnecessarily in the evaporator. In the present invention this has been accomplished by providing a thermostatic expansion valve for controlling the flow of refrigerant through the liquid line to the evaporator, the operation of the expansion valve being controlled by the temperature of the suction line and the pressure existing in the evaporator. In the present day installations of this type, location of the control bulb upon the suction line usually has the effect of shutting off the expansion valve for a short interval after the machine has ceased to operate, but fails to control the flow of refrigerant to the evaporator or maintain such flow stopped after this interval has elapsed. This is caused by circulation of the relatively warm air within the provision chamber of the refrigerator which warms that portion of the suction line to which the control bulb is attached. A portion of the invention resides in means for maintaining the suction line, or the control bulb attached thereto, in its usual cool condition during the off-cycle of an intermittently operating refrigerant condensing unit.

This expedient for controlling refrigerant flow was so successful that smaller motors having lower torque characteristics were found to be adequate for driving the compressor. The maximum pressure in the evaporator is controlled and limited by the maximum pressure generated by the refrigerant charge in the control bulb so as to prevent the thermostatic expansion valve from admitting any more refrigerant to the evaporator than would raise the evaporator pressure to the bulb limit. It will be understood, however, that this pressure might slightly exceed the maximum pressure of the bulb by reason of the vaporization of refrigerant in the evaporator during the off-cycle, but such excess pressure will be relatively negligible because of the rather small quantities of liquid refrigerant with which a continuous coil evaporator normally operates, and such pressure will be reduced almost instantaneously upon the beginning of the on-cycle. The capacity of a given size of motor could thus be increased, by increasing the compressor displacement when using a thermostatic expansion valve with its bulb so located, but this does not insure against a reduction in the efficiency of the apparatus during all phases of its operation.

This reduction in efficiency is particularly noticeable, for example, during long drawn out running periods as when a heavy load is thrown upon the machinery during ice freezing. In such an instance the wattage input to the motor is rather low, but the winding temperatures rise to an excessive figure; consequently, it is necessary to provide a motor of large enough size so that for a given load winding temperatures do not rise much above two hundred degrees Fahrenheit.

In order to maintain the winding temperatures below such a figure without an increase in capacity of the motor, a jacket has been provided about the motor through which refrigerant, which

has been condensed, is permitted to flow to abstract heat from the motor. This refrigerant, which will be vaporized by the heat of the motor, is then returned to a second section of the condenser where it is again liquefied prior to being passed on to the evaporator.

With the foregoing general description in view, the invention will be recognized as having for its object the increase of the capacity of a refrigerating system without material alteration thereof and without adding to the cost of the system.

It is an object of the invention to provide in combination with a condensing unit a jacket about the motor of the condensing unit, which jacket is supplied with refrigerant which is condensed in a portion of the condenser and is returned to another portion of the condenser after flowing through the motor jacket.

It is a further object of the invention to provide means whereby the suction line and the liquid line are in heat exchange relation so that the efficiency of the system is improved.

An additional object of the invention is to provide means in a system employing a thermostatic expansion valve for controlling the evaporator pressure for preventing such pressure from rising unduly above the limiting pressure as determined by the charge in the bulb of the thermostatic expansion valve.

It is a further object of the invention to provide means for preventing the flow of refrigerant to the evaporator of an intermittently operating refrigerating system during the off-cycle of the system.

It is a further object of the invention to provide means whereby the control bulb of a thermostatic expansion valve derives its temperature from the suction line during the on-cycle of an intermittently operating refrigerating system and derives its controlling temperature, during the off-cycle of the system, from the evaporator.

A further object of the invention is to provide means whereby the control bulb of a thermostatic expansion valve and the suction line to which it is secured for controlling the flow of liquid into the evaporator are not unduly heated or have such heat rapidly conducted away during the off-cycle of an intermittently operating refrigerating system.

Further objects will appear hereinafter as the description proceeds and will be pointed out more particularly in connection with the appended claims.

For a more complete understanding of the invention, attention is directed to the drawings of which there are two (2) sheets, and in which:

Fig. 1 is a diagrammatic sectional and elevational view of a refrigerator cabinet and refrigerating system which embodies the invention;

Fig. 2 is a detail elevational view of the rear portion of the evaporator and thermostatic expansion valve, looking toward the front portion of the cabinet;

Fig. 3 is a detail view of a portion of an evaporator and suction line illustrating an alternative method of connecting the control bulb of a thermostatic expansion valve to the suction line;

Fig. 4 is a detail sectional view of the expansion valve shown in Figs. 1 and 2; and,

Fig. 5 is a side elevational view, partially in section, of a switch and operation regulating mechanism for controlling the supply of electricity to the motor of the refrigerating system.

Similar reference characters are employed to designate similar parts throughout the specification.

Referring particularly to Fig. 1, a cabinet indicated generally at 10 contains a food compartment tank 12, which is entirely surrounded by heat insulating material 14 and which carries in its upper portion an evaporator indicated generally at 16, in which liquid refrigerant is adapted to be vaporized. The evaporator 16 comprises a sleeve 18, which has its open end closed by a door 20 provided with a handle 22.

Upon the sleeve 18 there are wound a series of turns of tubing 24 within which the refrigerant is vaporized. The refrigerant is supplied to the evaporator from a liquid line 26 through a thermostatic expansion valve 28 and a short length of tubing 30 which connects the expansion valve and the coils of tubing 24. Refrigerant vapor is withdrawn from the evaporator through a suction line 32, which has a portion 34 leading downwardly along the rear closed end 36 of the evaporator. This downwardly extending length of tubing 34 terminates in a return bend 38 which leads upwardly into a section 40 of enlarged inside diameter for preventing liquid refrigerant which might possibly find its way into the suction line from being carried over into the suction side of the compressor. After its passage through the portion 40 of enlarged diameter, the refrigerant vapor enters a section of tubing 42 which extends to the suction side of the compressor indicated generally at 44. This section of tubing 42 may be arranged parallel to and in thermal conducting relationship with the liquid line 26 throughout a portion of their extent so as to provide a heat interchanger or heat exchange device for increasing the efficiency of the system.

The motor-compressor 44 is illustrated as being of the hermetically sealed type in which a motor and compressor are enclosed in a single casing to eliminate the necessity for the use of a shaft seal; it will be understood, however, that this disclosure is only for the purposes of illustration and that the motor and compressor could be separate and still enjoy all of the advantages inherent in the invention. The compressor is shown to be of the rotary type, but it will be understood that any other desired type of compressor 46 could be employed.

The motor 48 occupies the upper portion of a sealed casing 50 while the compressor 46 is located in the lower portion thereof. Suitable electrical connections 52 connect the windings of the motor to an electrical plug 54 and a switch 56, the construction of which will be more fully explained hereinafter.

Refrigerant which has been withdrawn from the evaporator through the suction line 42 is compressed in the compressor 46 and is discharged into the casing 50 from which point it is led away to a condenser 58 by means of a discharge line 60.

The condenser 58 is illustrated as comprising a series of parallel lengths of tubing 62 which are threaded through cross fins 64 and comprises two sections. The first section 66 to which the discharge line 60 is connected serves to condense and liquefy the refrigerant which is expelled from the casing 50.

From the first section of the condenser a line 68 extends to a jacket 70 arranged exteriorly of the casing 50 and surrounding the windings 72 of the motor 48. The line 68 delivers liquid refrigerant into the jacket 70 where such refrigerant absorbs heat which is generated by the motor

windings 72. This absorption of heat may result in vaporization of a portion or all of the liquid refrigerant which is supplied to the jacket 70 and such vaporized refrigerant is withdrawn from the upper portion of the jacket 72 by means of a line 74, whence it is conducted to a second section 76 of the condenser 58 and in which second section the refrigerant, which may have been vaporized in the jacket 70, is recondensed and reliquefied.

After terminating its passage through the second section 76 of the condenser 58 the liquefied refrigerant is permitted to pass through the liquid line 26 under the regulation which is set up by the thermostatic expansion valve 28.

The thermostatic expansion valve 28, illustrated more completely in Fig. 4, includes a body portion 78 having a longitudinally extending passage 80 provided therein and to which passage 80 the flanged end 82 of the refrigerant line 26 is secured by suitable fittings indicated generally at 84. A strainer 86 may be provided in the passage 80 to intercept any foreign matter which may get into the system and might tend to clog the needle of the expansion valve 28 and prevent its proper seating.

From the passage 80 a second passage 88 leads to the valve proper which is positioned within a chamber 90 formed in the body 78 of the expansion valve. The seat 94 of the valve is pressed into a fitting 92 threaded into a wall extending between the passage 88 and the chamber 90, and this seat is adapted to be engaged by a needle 96 which is floatingly carried in a support illustrated generally at 98, the support 98 and the needle 96 being pressed toward closing position by an adjustable spring 100. The adjustment of the spring 100 is accomplished by rotation of a threaded plug 102 in a tapped opening in a fitting threaded into the body 78 of the valve 28. This adjustment is performed at the factory and further disturbance of the adjustment prevented by solder 104 which covers the head of the plug 102.

The needle support assembly 98 derives its movement from push pins 106 which are fitted against an equalizer disk 108 carried upon the assembly 98. The opposite ends of the push rods 106 extend through the end wall of the body 78 of the valve 28 and into contact with one portion 110 of a flexible diaphragm indicated generally at 112. The periphery of the diaphragm 112 is tightly clamped between an annular shouldered portion 114 provided upon the valve body portion 78, and a ring member 116 soldered at 118 to the body member 78. A second ring member 120 is tightly secured to the first ring member 116 and provides a support between itself and a cap 122 for a second or power element diaphragm illustrated generally at 124. A push rod 126, shown in the present case as being hollow, connects the facing portions of the two diaphragms and is rigidly secured to each of them. A spring 128, which extends between the cap 122 and diaphragm 124, tends to urge the diaphragms toward the right as viewed in Fig. 4 to act to restore the diaphragms after a deformation to the left.

A tube 130, which opens into the cap 122, has its opposite end closed at 132 after the tube and the cap 122 have been filled with the same refrigerant as is to be employed in the system but under a pressure of approximately five pounds per square inch.

The free end 134 of the tube 130 forms a bulb for controlling the operation of the diaphragms 112 and 124, and, consequently, the operation of the needle 96, and to this purpose the free end 134, in the embodiment disclosed in Figs. 1 and 2, is disposed partially in contact with the downwardly extending portion 34 of the suction line 32 and partially in contact with the rear wall 36 of the evaporator sleeve 18, the rear wall 36 serving as a heat conducting fin which is attached in thermal conducting relationship to the coils 24 of the evaporator (see Fig. 2). From the chamber 98 the refrigerant which passes the valve 94, 96 flows into the line 30 which leads to the coils 24 of the evaporator.

With this valve arrangement the body diaphragm 112 responds indirectly to the pressure which exists within the evaporator and in the suction line and opens the valve when that pressure is increased. The power element diaphragm 124 presses against the push rod 126 so that any increase in the pressure of the power element will open the valve when that pressure is greater than the low side or evaporator pressure. The power element which includes the tube 130 and cap 122 is charged with refrigerant and therefore the pressure on the diaphragm 124 depends upon the temperature of the feeler bulb 134. The valve, therefore, is indirectly controlled in accordance with the pressure in the evaporator as a result of changes in the temperature of the feeler bulb, since the evaporator pressure depends upon its temperature, and therefore the valve really is controlled by the differences in temperature of the refrigerant in the evaporator and the refrigerant in the tube 130 or the super heat of the refrigerant in the evaporator.

Ordinarily, in this type of valve, the expansion valve bulb is located on the suction line or on the front of the evaporator a short distance from the last pass of the evaporator coil. If it is located on the suction line the bulb warms up rapidly during the off-cycle and opens the valve, allowing the liquid to leak through the expansion valve needle slowly. If the bulb is located on the evaporator sleeve the temperature of the evaporator will correspond to the super heat setting of the valve and an appreciable loss of efficiency will result because the last two or three coils of the evaporator will not be filled with refrigerant.

With an arrangement such as is shown in the drawings the temperature of the back sleeve is appreciably above that of the tubes or coils of the evaporator during the on-cycle of the machine. During the off-cycle, however, the difference in temperature is much less and tends to approach the tube temperature to within two or three degrees; this keeps the bulb temperature at a point above the temperature of the tubes which is less than the super heat setting of the valve and consequently the valve will not open to let refrigerant leak through. The enlarged section 40, which is provided in the suction line has the purpose of preventing any small quantities of liquid refrigerant which may be in the evaporator at the start of the on-cycle from slugging back to the compressor.

Operation of the system is controlled by a switch 56 (see Figs. 1 and 5). Switch 56 comprises a body or casing 136 which may be supported upon the evaporator in any suitable manner and which contains therein mechanism for establishing and interrupting a circuit through the lines 52 through the compressor. The lines 52 may be connected by a suitable female plug to a male plug 138 carried upon one surface of the

body member 136. One of the contacts of the male plug 138 is connected to a stationary contact point 140 while the other of the members 138 is connected to a bust bar 142 which has electrical connection through a length of flexible cable 144 to the movable lever element 146 of the switch.

Lever element 146 is pivoted at 150 and supports upon a leaf spring 152 a contact element 154 for cooperation with the stationary contact button 140. A projecting portion 156 of the lever 146 carries a depending coil spring 158 which has its opposite end hooked around a link 160, pivotally carried by the free upper end 162 of an actuating lever 164.

The actuating lever 164 is pivoted at 166 to the casing and is arranged to derive its movement from a bellows 168, the free end 170 of which has a projecting portion 172 providing a seat for a washer 174 bearing against the lever 164. The opposite end of the bellows 168 is rigidly secured at 176 to a cap 178 held by bolts 180 to the casing 136. The cap 178 has a fitting 182 which attaches a tube 184 to the cap 178 in open communication with the bellows 168. The free end of the tube 184 terminates in a bulb 186 which is arranged upon the evaporator sleeve 18 and is subjected to the temperatures which prevail at that point. The bulb 186 and tube 184, as well as the bellows 168 and the cap 178, are filled with an expansible fluid.

It will be recognized that as the temperature upon bulb 186 increases, the pressure of the fluid therein will be increased and will result in movement of the free end of the bellows 168 toward the left as viewed in Fig. 5 and in a counterclockwise movement of the lever 164 about the pivot 166 to swing the upper end of the lever to the left as viewed in Fig. 5. This swinging movement of the lever to the left stretches the spring 158 and causes it to snap the switch lever 146 in a clockwise direction and bring the contact points 154 and 140 into electricity conducting relationship, thus establishing a circuit to the motor of the compressor unit.

The switch 56 is also provided with means for overbalancing the force exerted by the bellows 168. To this end, a compression spring 188 is positioned to bear against that side of the lever 164 opposite the bellows 168, the opposite end of the spring 188 being confined by a cup-shaped washer 190 threaded upon a shaft 192 which extends through a wall 194 of the casing and terminates in a control knob 196 exteriorly of the casing 136. It will be recognized that rotation of the shaft 192 by means of the knob 196 will result in increasing or decreasing the loading of the spring 188 and, accordingly, will either increase or decrease the pressure which must be developed within the bellows 168 in order to swing the contact point 154 into engagement with the contact point 140.

A stop 200 is formed integral with an inside wall of the casing and provides a surface against which a projection 202 of the lever 164 may abut to prevent undue rotation of the lever 164 in a counterclockwise direction. Stops 204 are provided upon the inside wall of the casing adjacent the link 160 to limit the swinging movement of the link 160 under the impetus of the spring 158. The lower end 206 of the lever 146 has a portion which projects into a slot (not shown) in the wall 194 and is adapted to be engaged by a projection 207 integral with the shaft 192 when the shaft is rotated to its limit of movement in a counterclockwise direction as viewed from the left in Fig. 5. Such rotation and engagement of these two members will swing the contact button 154 out of contact with the button 140 to interrupt their engagement and maintain the circuit to the motor permanently interrupted. This expedient is employed for the purposes of defrosting the evaporator.

In Fig. 3 there is shown an alternative method of connecting the control bulb to the suction line. In this embodiment of the invention, the suction line 32 passes through insulating material 220 which insulating material serves to protect this section of the suction line from the relatively high temperatures which may prevail in the food compartment of the refrigerator. The bulb 134 of the thermostatic expansion valve 28 is arranged in contact with the suction line 32 within the insulating material 220, being located in a chamber 222 provided in the mass of insulating material 220. With this arrangement the insulating material serves to maintain the temperature of the suction line at a temperature which corresponds to the temperature of the refrigerant therein and prevents the control bulb 134 from warming up during the off-cycle of the machine and from opening the valve to permit refrigerant to flow past the needle 96.

It is contemplated that any desired means may be employed for preventing the expansion valve bulb from warming up too rapidly during the off-cycle of the machine.

While the invention has been described with some detail, it is to be understood that the description is for the purpose of illustration only and is not definitive of the limits of the inventive idea. The right is reserved to make changes in the details of construction and arrangement of parts as will fall within the purview of the attached claims.

I claim:

1. A refrigerating system comprising an evaporator, means for supplying fluid refrigerant to said evaporator and for evacuating fluid refrigerant from said evaporator, including means for controlling the flow of refrigerant to said evaporator, said control means comprising a valve and means responsive to the heat existing in the discharge portion of said evaporator and to the heat existing in a fin forming part of said evaporator for operating said valve.

2. A refrigerating system comprising a finned refrigerant evaporator, a line for carrying liquid refrigerant to said evaporator, a suction line for withdrawing vaporous refrigerant from said evaporator, an expansion valve located in the liquid line for controlling the flow of liquid to the evaporator, and control means for said valve including a bulb disposed in thermal conducting relation with the suction line and with a fin of said evaporator.

3. A refrigerating system comprising an evaporator, a line for supplying liquid refrigerant to said evaporator, a suction line for withdrawing vaporous refrigerant from said evaporator, an adjustable orifice in said liquid line, and means for controlling the size of said orifice including thermally actuated means deriving its temperature partially from the temperature of the suction line and partially from a relatively colder heat conducting surface of said evaporator.

4. A refrigerating system comprising an evaporator having refrigerant conducting portions and portions spacing and supporting said refrigerant conducting portions, a line for supplying

liquid refrigerant to said evaporator, a suction line for withdrawing vaporous refrigerant from said evaporator, means for reducing the pressure on and controlling the flow of the liquid refrigerant to said evaporator including thermally actuated means adapted to derive its temperature in part from the temperature of the suction line and in part from the temperature of said evaporator spacing and supporting portions.

5. In a refrigerating system, a compressor arranged to be operated intermittently, an evaporator, liquid and suction lines connecting the compressor and evaporator, means controlled by the temperature and pressure existing in the suction line for regulating the flow of refrigerant through the liquid line, and means for maintaining a low suction line temperature during the off-cycle of the compressor.

6. In a refrigerating system, a compressor arranged to be operated intermittently, an evaporator, liquid and suction lines connecting the compressor and the evaporator, means controlled by the temperature and pressure existing in a portion of the suction line for regulating the flow of refrigerant through the liquid line, and means for maintaining said portion of the suction line in cooled condition during the off-cycle of the compressor.

7. In a refrigerating system, a motor-compressor arranged for intermittent operation, an evaporator, a condenser for condensing refrigerant discharged from the compressor, a liquid line connecting the condenser and evaporator, a suction line connecting the evaporator and compressor, means controlled by the temperature and hence in accordance with the pressure of the suction line for regulating the flow of refrigerant through the condenser and liquid line, and means for maintaining the suction line in cooled condition during the off-cycle of the compressor, said condenser including an intermediate portion for supplying cooled refrigerant to the motor of the motor-compressor.

8. In a refrigerating system, flow control means for the refrigerant having an actuating member positioned upon the suction line of the system, and means for maintaining said flow control means in cooled condition during all stages of operation of the system.

EARL F. HUBACKER.