

Aug. 16, 1955

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2,715,318

SEALED SYSTEM WITH REVERSE CYCLE DEFROSTING

Filed April 5, 1950

3 Sheets-Sheet 1

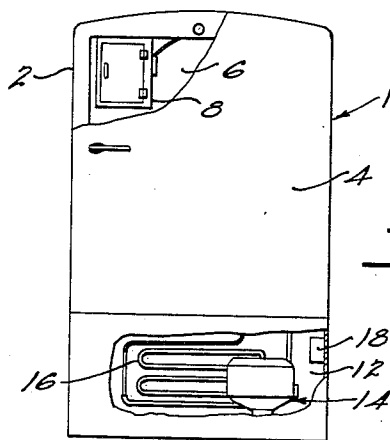


FIG. 1.

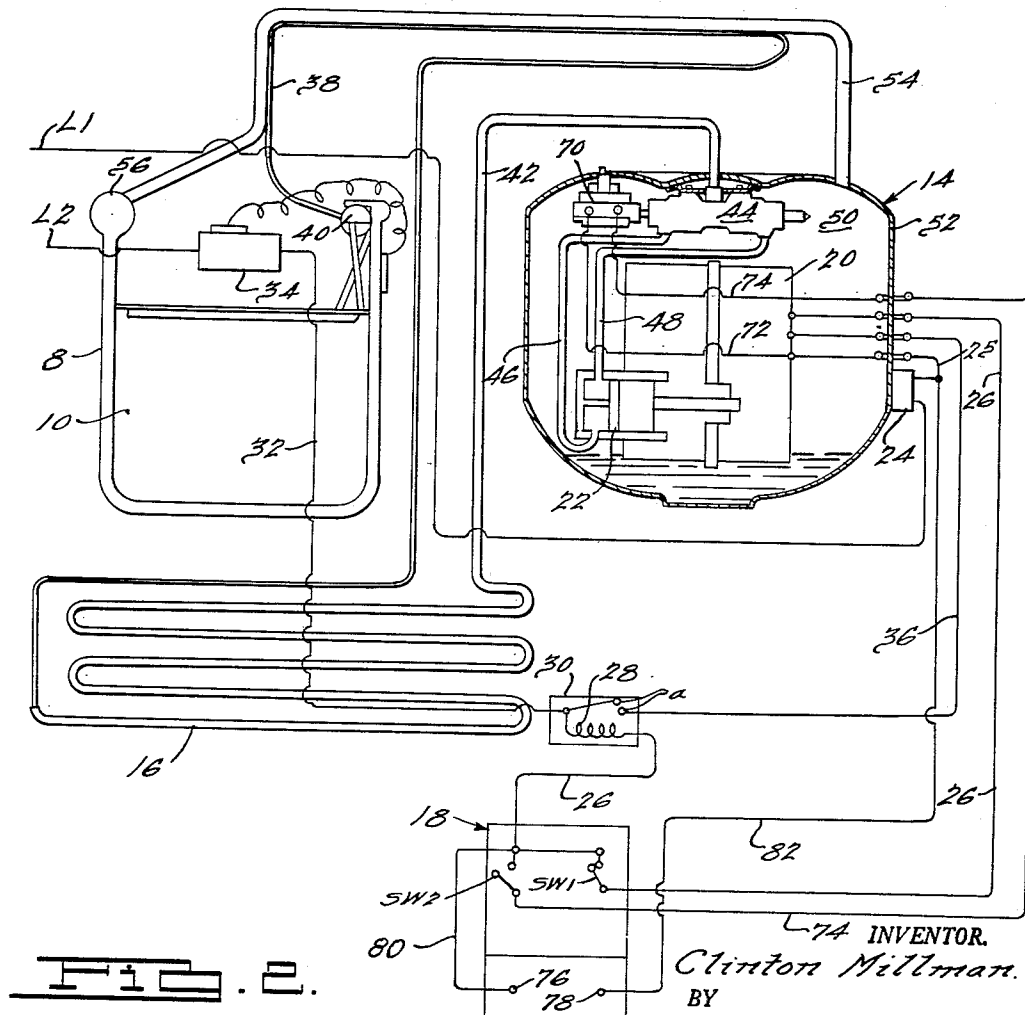


FIG. 2.

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3 Sheets-Sheet 2

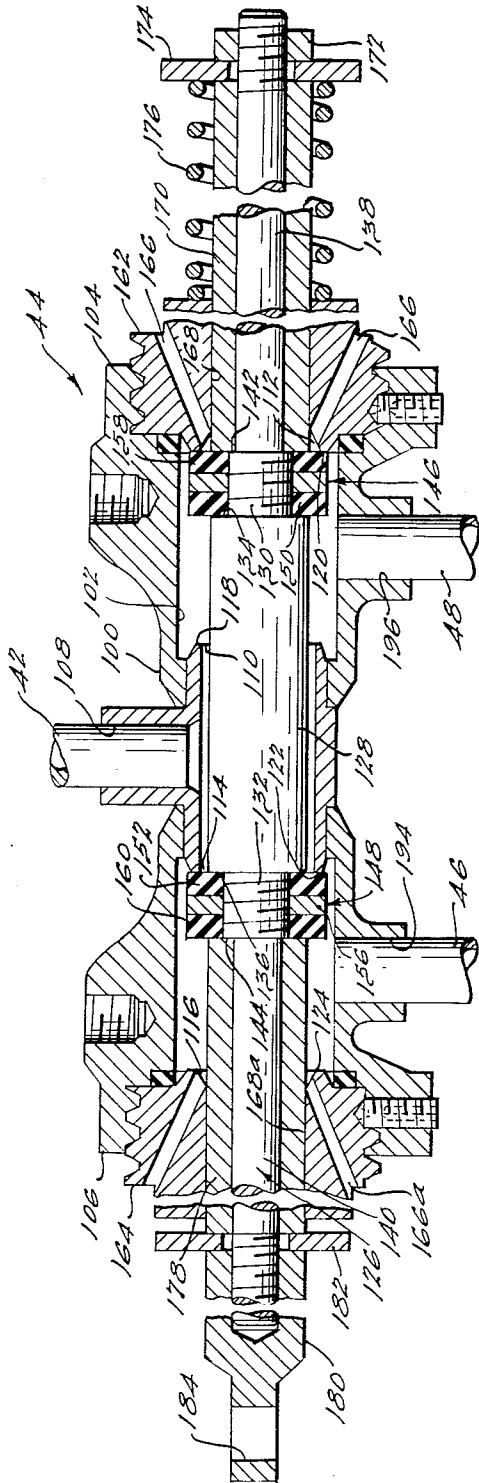
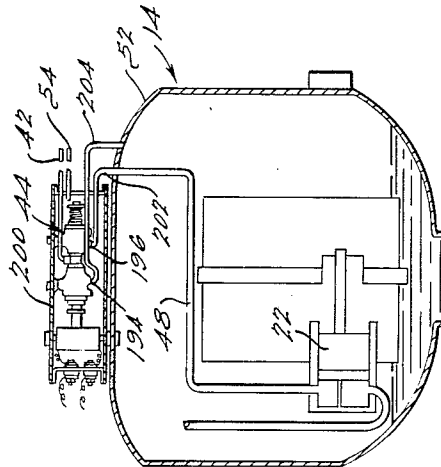


Fig. 3.

Fig. 4.

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3 Sheets-Sheet 3

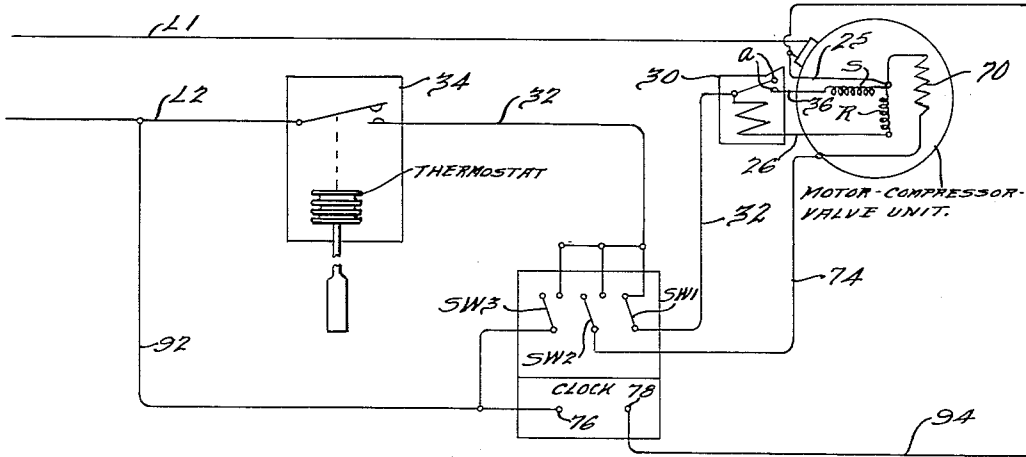


FIG. 5.

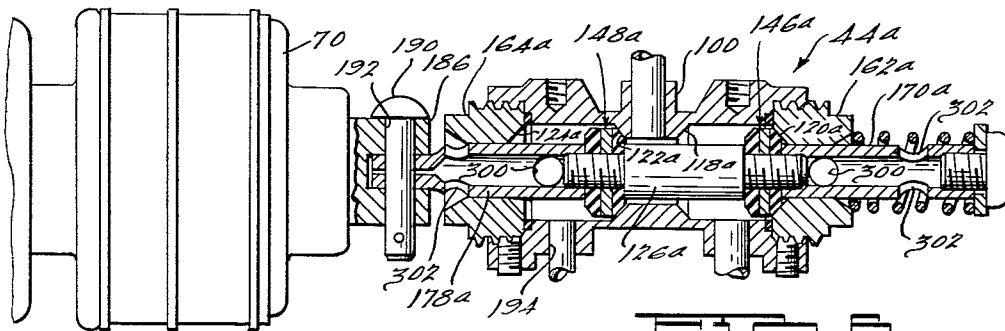


FIG. 6.

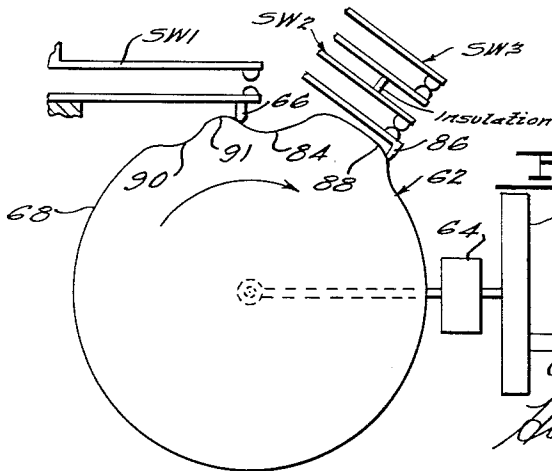


FIG. 7.

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2,715,318

## SEALED SYSTEM WITH REVERSE CYCLE DEFROSTING

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Application April 5, 1950, Serial No. 154,110

16 Claims. (Cl. 62—4)

This invention relates generally to the method of and apparatus for the control of refrigeration apparatus and is particularly adapted among other uses for defrosting domestic refrigerators.

Reversed cycle defrosting has been used in prior art refrigerating systems but, due to the complexity of the valving arrangement, has been limited exclusively to systems of the commercial type and has not been applied to the so-called household or domestic refrigerators. Defrosting in the household refrigeration art has been limited to the shutting down of the refrigerating unit and permitting the low side thereof to gradually warm up permitting the accumulated frost to melt and drip from the evaporator unit. With the appearance of the domestic refrigerator in which comestibles are stored in two zones, one in a freezing zone in which the comestibles are maintained in a frozen condition below 32° F. and another section in which comestibles are maintained in a nonfreezing condition, the limitations of this type of defrosting were such that it is no longer practical since the food stuffs stored at the lower or freezing temperature would melt and such defrosting could only be carried with the frozen comestibles storage compartment empty. I am aware that various efforts have been made to adapt the reverse cycle of defrosting to such household units but such an arrangement has not met with success.

It is therefore a primary object of this invention to provide a new defrosting arrangement for household refrigerators for quickly defrosting the evaporator unit without a corresponding rise in temperature of the comestibles refrigerated thereby.

Another object of this invention is to provide such a system in which for short periods of time the normal evaporator serves as a condenser and the normal condenser serves as an evaporator for reverse cycle defrosting in which heat is applied at the proper point for defrosting the evaporator without appreciably raising the temperature of the stored comestibles.

Another object of this invention is to provide such a reverse cycle defrosting system which is particularly adapted for use on the usual capillary tube type hermetically sealed domestic refrigeration system.

Another object of this invention is to accomplish a rearrangement of the refrigerating system elements for reverse cycle refrigeration by means of a valve located within the sealed refrigeration system.

Another object of this invention is to provide an improved valve arrangement which is of minimum size and which will require a minimum operating force.

Another object of this invention is to provide a new control system for controlling defrosting by a reverse cycle operation.

A more specific object of this invention is to provide such a defrosting cycle which will operate after predetermined running time of the motor-compressor unit which is of course a function of the amount of frost accumulated on the evaporator.

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Another object of this invention is to provide a defrosting cycle in which the pressures in the system are substantially balanced before the reverse cycle operation is started so that the valve may be positively operated with a minimum amount of force.

Another object is to provide such a system in which the defrosting cycle is initiated by a de-energized time period of the motor compressor unit of predetermined length, a predetermined length of reverse cycle operation following by a predetermined length of de-energized condition of the motor compressor unit prior to its being restored to normal operation.

Another specific object of this invention is to provide such a defrosting system in which the reverse cycle operation of the refrigerating system is accomplished independently of any action of the normal control for the refrigerating system.

Another object is to provide a hermetically sealed valve unit of minimum size which is particularly adapted for use with domestic refrigerated systems.

Other objects of the invention will be apparent from the specification, the appended claims and the drawings in which drawings:

Figure 1 is a view of a domestic refrigerator with certain parts broken away and embodying the invention;

Fig. 2 is a diagrammatic view of a refrigerating system embodying the invention showing the refrigerating system and the electrical control system;

Fig. 3 is a view in central vertical cross section of the valve shown in Fig. 2 within the hermetically sealed motor compressor unit;

Fig. 4 is a view showing a modified form of the invention in which the hermetically sealed valve unit is located externally of the motor compressor unit;

Fig. 5 is a view showing a modified form of electrical control system;

Fig. 6 is a view partially in central vertical section of a modified form of the valve unit and including the actuator therefor; and

Fig. 7 is a view showing certain details of the mechanism for controlling the reverse cycle operation.

Referring to the drawings by characters of reference, the numeral 1 indicates generally a household type of refrigerator having a cabinet 2 with an access door 4 and containing a compartment 6 adapted to be maintained at temperatures above freezing, an evaporator 8, the interior of which provides a frozen storage compartment 10 which may, for example, be maintained at about 0° F. The cabinet 1 further includes a high side containing compartment 12 in which is located a hermetically sealed motor compressor unit 14, a condenser 16 and a control mechanism 18. The unit 14, condenser 16, and evaporator 8 are connected together into a sealed system.

As will be seen in Fig. 2 the motor compressor unit 14 includes a motor 20 which may be of the usual low starting torque split phase type driving a pump or compressor 22. The motor 20 contains the usual starting and running windings (not shown in Fig. 1 but shown as S and R in Fig. 5) which are energized from a suitable source of electrical energy such as lines L1, L2. Line L1 is connected through a suitable overload device 24 and line 25 to the common connection between the starting and running windings. The other terminal of the running winding is connected through conductor 26 and switch SW1 of the control mechanism 18 to one end of the coil 28 of the starting relay 30. The other end of the coil 28 is connected through a conductor 32 and control switch 34 to the line L2. The other terminal of the starting winding is connected by conductor 36 through the switch contacts a of the relay 30 to the conductor 32.

Upon closure of the switch 34 due to a rise in temperature of the evaporator 8 the starting and running windings

of the motor 20 will be energized for starting the motor 20. As is normal, the heavy starting current drawn by the running winding flowing through the relay winding 28 of the starting relay 30 will close the contacts *a* of the relay 30 whereby the motor starting winding is energized and the motor will start. After the motor has increased in speed sufficiently so that it will operate on single phase current flowing through the running winding, the current through the relay winding 28 will have dropped sufficiently to permit the contacts *a* of the relay 30 to open thereby de-energizing the starting winding. The motor will continue to operate from the running winding in the usual fashion.

The evaporator 8 is supplied with liquid refrigerant from the condenser 16 through a suitable feed device such as the capillary tube 38 discharging into the liquid receiving header 40 of the evaporator 8. This tube 38 acts during the off time or nonrunning condition of the motor compressor unit 14 to equalize the pressures in the system. The condenser 16 is in turn connected by means of conduit 42 through the valve device 44, to be more fully described below, through the conduit 48 to the discharge port of the compressor 22. The intake port of the compressor 22 is connected through conduit 46 and the valve 44, located within the interior 50 of the housing 52 which encloses the motor 20 and compressor 22, to the interior 50 which in turn is connected by means of a suction conduit 54 with the discharge header 56 of the evaporator 8.

During normal operation of the refrigerating system vaporous refrigerant will be drawn from the header 56 of the evaporator 8 through the conduit 54, the interior 50 of the housing 52, the valve device 44, conduit 46 into the compressor 22 wherein the refrigerant is raised in pressure and discharged through the conduit 48, valve device 44, conduit 42 into the condenser 16 wherein its heat is radiated and the vapor is condensed to a liquid which then flows through the capillary tube 38 to the inlet header 40 of the evaporator 8. Liquid flowing into the header 40 flows around through the evaporator absorbing heat which causes it to vaporize which vaporous refrigerant finds its way to the discharge header 56 for subsequent recirculation.

The control mechanism 18 includes a self-starting synchronous motor 60 (Fig. 7) which may be of the electric clock type which drives a switch actuating or cam disk 62 through a suitable gear reduction 64. The disk 62 in turn controls the opening and closing of switches SW1, SW2 and SW3. In the form of the invention shown in Fig. 2 only two switches SW1 and SW2 are used and therefore, for purposes of simplicity, the third switch SW3 shown in Fig. 7 is omitted from the showing of the mechanism 18 in Fig. 2. The switch SW1 is located in series in the conductor 26 and as shown in Fig. 2 is located intermediate the relay 30 and the running winding of the motor 20. Normally switch SW1 is held closed since during substantially the entire rotation of the disk 62, the disk follower 66 thereof rides on the normal diameter circular peripheral surface 68 of the disk 62. Therefore, during normal operation of the refrigeration system, the switch SW1 is maintained closed whereby control of the starting and stopping of the motor 20 is effected by means of the control switch 34.

The valve device 44, to be described in greater detail below, is shiftable by means of the solenoid actuator 70 to a position in which the refrigerant will be directed as described above and to a second position in which the conduit 46 is connected to the conduit 42 whereby the compressor will withdraw vaporous refrigerant from the condenser 16 and discharge it through the conduit 48 and the valve device 44 into the interior 50 of the housing 52 from whence it flows outwardly through the conduit 54 to the evaporator 8. The high pressure refrigerant flows into the evaporator 8 whereby its heat of condensation heats the evaporator and the resulting condensed liquid refrigerant flows through the capillary tube 38 back

to the condenser 16 wherein it is vaporized due to absorption of heat therefrom. The vapor then flows through the conduit 42 back to the compressor 22 for recirculation in the refrigerating system substantially as just described.

One terminal of the energizing winding of the solenoid actuator 70 is connected by means of conductor 72 through device 24 to the line L1. The other terminal of the winding of this actuator 70 is connected by means of conductor 74 to one terminal of the switch SW2. The other terminal of this switch SW2 is connected to the conductor 26 intermediate the switch SW1 and the winding 28 of the relay 30. The motor 60 (Fig. 7) is provided with terminals 76 and 78. The terminal 76 is connected by means of conductor 80 to the portion of the conductor 26 connected in common to the switches SW1 and SW2. The terminal 78 is connected by means of conductor 82 to the line 25 so that opening of the overload device 24 will stop the motor 60. It will be seen that the motor 60 is energized from the lines L1 and L2 upon closure of the control switch 34 through a circuit which extends from the line L1 through the conductors 25 and 82, the clock motor 60, conductor 80, portion of the conductor 26, relay winding 28, conductor 32, switch 34 back to the line L2 and the clock will act to measure running time of the compressor. Once each revolution of the disk 62, the disk follower 66 will drop down into the depression or recess 84 and permit the switch SW1 to open. Opening of the switch SW1 de-energizes the motor 20 permitting pressures within the refrigerant system to equalize through the constantly open capillary tube 38.

After continued predetermined rotation of the disk 62, the disk follower 86 of the switch SW2 will have been pushed upwardly by the abutment or enlargement 88 of the disk 62 to close the switch SW2. It should be recalled that during this time the switch 34 is in closed position calling for the motor compressor unit 14 to remove heat from the evaporator 8. Closure of the switch SW2 acts to energize the solenoid actuator 70 through a circuit which extends from line L1 through the overload device 24, conductor 72, actuator 70, conductor 74, switch SW2, conductor 26, winding 28, conductor 32, switch 34 to line L1. Energization of the actuator 70 shifts the valve device 44 into a position in which the condenser 16 acts as an evaporator and the evaporator 8 acts as a condenser. Shortly thereafter the disk follower 66 of the switch SW1 will ride up the side of the depression 84 to close the switch SW1. Closure of switch SW1 energizes the normal circuit of the motor 20 whereby the motor 20 operates to drive the compressor 22 for withdrawing refrigerant from the condenser 16 and discharging it into the evaporator 8. Heat is thus removed from the condenser 16 and deposited in the evaporator 8 which quickly raises the temperature of the evaporator 8 and permits the frost accumulated thereon during the refrigerating cycle of the evaporator 8 to melt and disengage itself from the evaporator.

After a predetermined reverse cycle operation of the motor compressor unit 14, the disk 62 will have rotated sufficiently to permit the disk follower 66 to drop into the depression 90 of the disk 62 opening the switch SW1 and de-energizing the motor 20 again permitting the pressures in the refrigerant system to equalize. Subsequently the disk follower 86 of the switch SW2 will have passed beyond the abutment 88 so that the switch SW2 will open to de-energize the actuator 70. As the pressure within the valve device 44 and the refrigerating system will already have or is about equalized, the valve device 44 will shift, in a manner to be described below, back to its normal position in which it directs the discharge of refrigerant from the compressor 22 into the condenser 16 and from the evaporator 8 to the compressor 22. After sufficient time has been allowed for this operation, the disk 62 will have been rotated so that the disk follower 66 will then be riding on the normal diameter portion 68 whereby the

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switch SW1 is again closed. Closure of the switch SW1 transfers control of the motor compressor unit 14 to the normal control switch 34. The switch 34 being closed, the motor 20 is again energized for operation of the compressor 22 as described above and refrigerant is then withdrawn from the evaporator 8, discharged into the condenser 16 where it is liquified and flows through the capillary tube 38 into the evaporator for recycling where- by the heat is removed from the evaporator and dis- charged from the condenser. The disk follower 86 is so arranged relative to the disk 62 that the switch SW2 will be closed only during the time that it is riding on the abut- ment 88. The disk follower 86 may or may not ride down into the depressions 84 and 90 but this is immate- rial since the switch SW2 will remain open at all times ex- cept when it is riding on the abutment 88.

The form of control circuit shown in Fig. 5 is quite similar to that shown in Fig. 2 with certain exceptions described below. In this form the clock is arranged to be continually driven (except during periods when device 24 is open) and acts to place the refrigerating system in defrost or reverse cycle operation at fixed predetermined time periods irrespective of the operating time of the motor compressor unit 14. To accomplish this the terminals 76 and 78 of the clock are connected by means of con- ductors 92 and 94 respectively to the line L1 and conduc- tor 25. The switch SW3 which operates concurrently with the switch SW2 as shown in Fig. 7 is provided to insure continued operation of the motor 20 during defrosting in- dependently of the switch 34. As shown in Fig. 5 the switch SW1 is located in the conductor 32 between the re- lay 30 and the control switch 34 instead of in the conduc- tor 26 as shown in Fig. 2. One of the contacts of each of the switches SW1, SW2 and SW3 is connected together and is connected by means of conductor 32 through the control switch 34 to the line L2. During normal refrig- erating operation of the system, the switches SW2 and SW3 will be open and the switch SW1 will be closed as described in connection with Fig. 2. The operation of the motor 20 therefore will be under control of the switch 34. During reverse cycle defrosting however the switches SW2 and SW3 will also be closed as well as switch SW1 as indi- cated above. The switch SW3 acts to close a circuit be- tween the conductors 32 and 92 whereby switch SW3 con- nects the common terminals of the switches SW1, SW2 and SW3 to the line L2 through the conductor 92 in by- pass arrangement around the switch 34 so that defrosting in reverse cycle operation may be carried on independ- ently of the operative condition of the switch 34.

In Fig. 3, the valve device 44 is shown in greater de- tail. The device 44 includes an elongated casing 100 having a central passageway or port 102 which extends longitudinally through the casing 100 and opens outward- ly through the opposite end walls 104 and 106. Sub- stantially midway between the walls 104 and 106 the casing 100 is provided with an outwardly extending flow passageway 108 to which the conductor 42 may be con- nected. The casing 100 is provided with two pairs of oppositely facing valve ports 110, 112, 114 and 116 defined by valve seats 118, 120, 122 and 124 respectively. The valve seats are preferably all of equal diameter and are relatively thin in cross sectional area.

A cylindrical valve operating stem 126 extends com- pletely through the passageway 102 and has a central enlarged diameter portion 128 and adjacent intermediate diameter portions 130, 132 at either end of the enlarged diameter portion. These portions 130 and 132 may be externally threaded. Shoulders 134 and 136 are formed at the intersections of the intermediate diameter portions with the enlarged diameter portion 128. Ends 138 and 140 of the operating stem 126 outwardly of the inter- mediate diameter portions 130 and 132 respectively are of reduced diameter and form shoulders 142 and 144 at their intersections with the intermediate diameter portions 130 and 132.

Valve seat members 146 and 148 are carried on the intermediate diameter portions 130 and 132 of the oper- ating stem 126 and have seat engaging disks 150 and 152 which engage against the shoulders 134 and 136 respectively. The disks 150 and 152 are of larger di- ameter than the enlarged diameter portion 128 and en- gage alternately with the valve seats 118 and 122. The valve seat members 146 and 148 are each provided with a rigid intermediate member 154 and 156 which screw- threadedly engage the external threads of the intermediate diameter portions 130 and 132 to hold the disks 150 and 152 against the shoulders 134 and 136. The valve mem- bers 146 and 148 are further provided with a second set of disks 158 and 160 which are in face-to-face relation with the backing members 154 and 156 on the opposite side from the disks 150 and 152 and which may be ce- mented thereto if desired. The disks 158 and 160 en- gage respectively with the valve seats 120 and 124.

The opposite ends of the passageway 102 are of en- larged diameter and internally threaded for reception of externally threaded plug or end members 162 and 164. The inner surface of the plug member 162 defines the seat 120 which surrounds the port 112. The plug 162 is provided with a plurality of outwardly extending pas- sageways 166 which open inwardly into the port 112 and outwardly of the valve device 44 and is provided with a bore 168 aligned concentrically with the passageway 102. A hollow cylindrical sleeve 170 which slides over and is carried by the reduced diameter portion 138 of the operating stem 126 is journaled for sliding movement in the bore 168. The inner end of the operating stem 126 engages the adjacent surface of the disk 158 and holds this disk against the abutment 154. The sleeve 170 is in turn held in position on the operating stem 126 by means of a nut 172 threaded thereon and which holds a washer 174 against the outer end of the sleeve 170. A helical coil compression spring 176 is arranged concen- trically about the sleeve 170 externally of the plug 162 intermediate the adjacent end wall of the plug and the washer 174 and exerts a force urging the operating stem 126 into the position shown in Fig. 3 in which the disk 158 engages the seat 120 and the disk 152 engages the seat 122.

The plug 164 is similar to the plug 162 and includes passageways 166a and bore 168a in which is journaled a hollow cylindrical sleeve 178 which fits on and is carried by the reduced diameter portion 140 of the operating stem 126. The sleeve 178 holds the disk 170 in proper position against the backing member 156. The sleeve 178 is held in position by means of a nutlike member 180 threaded on the end of the operating stem 126 and holding a washer 182 against the sleeve 178. The nutlike mem- ber 180 is provided with a through aperture 184 which aligns with an aperture 192 of an operating stem 136 of a solenoid actuator not illustrated in Fig. 3 but identi- fied as 70 in Fig. 6. A pin or other suitable connecting means 190 (see Fig. 6) extends through apertures 184 and 192 to connect the actuator 70 to member 180.

Upon energization of the actuator 70, the stem 126 will be withdrawn inwardly toward the actuator moving the valve members 146 and 148 toward the left away from the ports 120 and 122 and into engagement with the ports 118 and 124. In this position of the valve device 44 the conduit 42 is connected through the port 114 to a casing port 194 opening outwardly through the casing 100 from the passageway 102 intermediate the ports 122 and 124. This port 194 is connected to the conduit 46 so that with the solenoid energized, the conduits 42 and 46 are connected together for permitting the com- pressor 22 to withdraw refrigerant from the condenser 16. At the same time the disk 50 will engage the seat 118 closing flow through the port 110 which normally connects the conduit 42 with a casing port 196 and the conduit 48 which is connected to the discharge port of the compressor 22 and placing the discharge conduit 48

in open communication with the interior 50 of the housing 52 through the port 112 and the passageway 166.

Upon de-energization of the actuator 70 spring 176 returns the valve device 44 to its normal position as shown in Fig. 3 in which the ports 112 and 114 are closed whereby the conduit 48 is in open communication with the conduit 42 through the port 110, and the conduit 46 is in open communication through the port 116 and passageway 166a with the interior 50 of the housing 52. The system is now in normal cooling condition in which the compressor is operable to draw vaporous refrigerant from the evaporator 8 through conduit 54, the interior 50 of the housing 52, the passageway 166a, port 116 and conduit 46 and discharging this vaporous refrigerant under pressure through the conduit 48 into the conduit 42 to the condenser 16.

It will be noted that there is a slight difference in area between that defined by the interior diameter of the seat 122 and that defined by the external diameter of the seat 120. Pressure within the space between the seats 122 and 120, with the valve in the position of Fig. 3, will therefore urge the valves into engagement with their seats. Since the usual operating differential across the seats may be in the general magnitude of upwards of 100 pounds per square inch, a substantial closing pressure acts to hold the valve in its set position. During the time switch SW1 is open, the compressor or pump 22 will stop operating and the pressures within the sealed refrigerating system will equalize through the tube 38. With the pressures balanced, the force due to fluid pressure biasing this valve to this position will, of course, disappear. When the pressure within the interior 50 of the housing 52 equalizes with that within the conduits 42 and 48, only friction and the force of spring 176 need be overcome by the solenoid actuator 70 to move the operating stem 126 to its actuated position in which the valve members 146 and 148 engage the seats 118 and 124. Upon operation of the compressor 22 in this position of the valve, pressure will again build up in the conduit 48 urging the valve member 146 tightly against the seat 118 and aid the solenoid actuator 70 in maintaining the valve device 44 in its actuated position. Upon termination of the reverse cycle operation of the system, the switch SW1 again opens and permits the pressure within the conduit 48 and interior 50 of the housing 52 to equalize with that within the conduits 42 and 46 so that upon de-energization of the actuator 70, the spring 176 will move operating stem 126 into its normal position.

In the modification shown in Fig. 4 the valve of Fig. 3 is placed within a sealed housing 200 which may be located externally of the housing 52 of the motor compressor unit 14. This construction is particularly advantageous where there is insufficient room within the housing 52 for the valve structure or to add such a structure to existing motor compressor units which have been fabricated without the valve device 44. In this construction the suction line 54 from the evaporator 8 opens into the interior of the housing 200. The port 196 is connected by means of conduit 202 to the conduit 48 which normally is brought out of the housing 52. The port 194 is connected by means of a conduit 204 to the interior of the housing 52. In other respects the operation and construction is similar to that shown in the form of Fig. 2.

In Fig. 6 there is shown a modified form of valve device 44a which may be used in place of the device 44 and in which like parts are indicated with like reference characters to the device 44 shown in Fig. 3. In this form, however, the plug or end members 162a and 164a are not provided with the passageways 166 or 166a since fluid flow through the end members 162a and 164a occurs through the hollow interior of the sleeves 170a and 178a. In this form the operating stem 126 is foreshortened so that its threaded end portions ter-

minate inwardly of the ends of the sleeves 170a and 178a which sleeves are interiorly screw threaded for reception in the end portion of the valve actuator 126a. The sleeves 170a and 178a are provided with spaced ports 300 and 302 which extend through side walls in these sleeves and alternately communicatively connect the interior of the valve housing 100 to the interior 50 of the casing 52. In the position shown in Fig. 6, which is the normal refrigerating position, the port 300 communicatively connects the port 194 with the interior of the housing 52 and ports 102 and 196 are connected together. With the valve operating stem 126a in its other or reversed cycle position, the port 300 of the sleeve 170a acts to communicatively connect the port 196 with the interior of the housing 52 and to connect port 194 with port 192. The valve members 146a and 148a are similar to the valve members 146 and 148 except they are provided with beveled seat engaging surfaces to engage the beveled valve ports 118a, 120a, 122a and 124a. It will be apparent that the valve members could be of metal and have ground seat engaging surfaces if desired.

During normal refrigerating operation of the refrigerating system of Fig. 2, the cam disk 62 will be engaging the disk follower 66 of the switch SW1 to maintain switch SW1 in closed position whereby the energization of the motor compressor unit 14 will be under control of the thermostatic control switch 34. The motor will be periodically energized and de-energized to drive the compressor 22 for withdrawing vaporous refrigerant from the evaporator 8 and discharging this vaporous refrigerant at high pressure into the condenser 16 in a normal manner to remove heat from the evaporator. The clock mechanism 18 is energized concurrently with the motor 20 to rotate the cam disk 62 which acts to add up the running time of the motor 20. After sufficient running time of the motor compressor unit has occurred in which an appreciative amount of frost may be expected to accumulate on the evaporator 8, the cam disk 62 will have been rotated to the position shown in Fig. 7 in which the cam disk follower 66 of the switch SW1 will have moved into the depression 84 opening the switch SW1 which breaks the circuit in the line 26 and prevents any running of the motor 20 to permit the pressures in the refrigerating system to equalize. After a predetermined time interval sufficient for this purpose, the disk 62 will have rotated sufficiently to cause the follower 86 of the switch SW2 to be raised by the enlargement 88 to close the switch SW2. A short time later the disk 62 will rotate sufficiently to cause the disk follower 66 to be raised by the enlargement 91 sufficiently to close the switch SW1. Closure of the switch SW2 acts to energize the solenoid actuator 70 for shifting the valve device 44 to close the ports 110 and 116 and open the ports 112 and 114 and the subsequent closure of switch SW1 starts the motor 20 after the valve device 44 has been shifted. The switch SW1 is maintained open due to the depressions 84 and 90 for a period sufficient to permit the pressures within the refrigerating system to substantially equalize whereby there are no refrigerant pressure forces acting to prevent movement of the stem 126 of the valve device 44.

It will be apparent that, with the circuit as disclosed in Fig. 2, the defrosting process of Fig. 2 is accomplished during an interval in which the temperature switch 34 is unsatisfied and is in the closed position for permitting operation of the motor 20 in which condition the motor 60 will be energized and drive the timing cam 62. Upon reclosure of the switch SW1 and energization of the motor 20 the pump 22 withdraws vaporous refrigerant from the condenser 16 and discharges it into the interior of the housing 52 from whence it flows through the conduit 54 into the evaporator 8. This vapor will then condense within the evaporator 8 imparting its heat thereto to melt the frost which has accumulated upon the

evaporator 8. Liquid refrigerant from the evaporator 8 flows through the small bore tube 38 into the condenser 16 where it is evaporated thereby absorbing heat from the condenser 16. This heat-laden vapor may again be withdrawn from the condenser 16 and discharged back to the evaporator 8 through the conduit 54 by the pump 22. At the end of a predetermined defrost time, the cam disk 64 will have been rotated sufficiently in a clockwise direction to permit the disk follower 66 to move into the depression 90 opening the switch SW1 and terminating operation of the pump 22. At some time thereafter, the disk follower 86 of the switch SW2 will pass from the enlarged cam portion 88 down to the normal diameter portion opening the switch SW2 to de-energize the solenoid actuator 70. As soon as the pressures within the system equalize which occurs as above set forth due to the open capillary tube 38, the spring 176 of the valve device 44 will move the operating stem 126 back to its shown position in Fig. 3. The length of time that the switch SW1 is held in open position by depression 90 of the cam 62 is sufficient to accomplish this equalization of pressures. After this predetermined time, the disk 62 will rotate still further in the clockwise direction lifting the disk follower 66 back to the normal diameter portion 68 of the cam 62 again reclosing the switch SW1 for normal refrigerating operation of the system under control of the switch 34.

The operation of the system shown in Fig. 5 is substantially the same as that shown in Fig. 2 except that the clock 18 is continually energized, it being supplied with energy from the lines L1 and L2 on the source side of the thermostatic switch 34. Therefore the defrosting operation in this system will occur periodically rather than as a function of compressor operating time. The switch SW3 is operated along with the switch SW2 to complete a circuit in parallel with the thermostatic switch 34 so that solenoid 70 and the motor 22 may be energized irrespective of the operating condition of the thermostatic switch 34. By the use of the particular type of valve structure and the particular timing mechanism, it is possible to provide a valve device which may be operated by a solenoid of minimum size and may be placed within the interior of most of the standard sealed motor compressor units now found on the market. The solenoid is not called upon to actuate the valve when there is any pressure differential acting to maintain the valve members against their respective valve seats and also during the running of the unit 14 the valves are held closed by the pressure difference maintained by the pump 22. In the preferred form of the invention the valve 44 or 44a is placed within the housing 52 of the motor compressor unit 14. In its more generic form the valve 44 or 44a is placed somewhere within the sealed refrigeration system. Furthermore, the invention contemplates such a unit which need not be provided with sealing means which would both be expensive and tend to increase the power required to actuate the valve device. Also, the invention contemplates a system in which minimum power is required to rearrange the system elements, and the apparatus for accomplishing the same is economical of construction and operation and requires a minimum of space.

What is claimed and is desired to be secured by United States Letters Patent is as follows:

1. In a domestic electric refrigerator, a refrigeration fluid system comprising an evaporator, a condenser, a compressor and a valve mechanism, means for driving said compressor, said valve mechanism being operable to connect said compressor to pump fluid from said evaporator to said condenser when in a first position and when in a second position to connect said compressor to pump fluid from said condenser to said evaporator, actuator means for moving said valve mechanism between said positions, a pair of control means one of said control means regulating the driving of said com-

pressor by said driving means and the other of said control means regulating the operation of said valve mechanism moving means, and means operating said pair of control means and effective to actuate said one control means to render said compressor driving means ineffective to drive said compressor and to maintain said other control means effective to actuate said valve moving means so that said valve mechanism can be actuated to one of its said positions during periods in which said compressor driving means is ineffective to drive said compressor, said last-named means thereafter actuating said one control means to drive said compressor and maintaining said other control means effective to maintain said valve moving means actuated.

2. The combination of claim 1 in which an unloader means is provided to balance the pressures across said valve mechanism during periods in which said compressor driving means is ineffective to drive said compressor and in which said one control means acts to maintain said compressor driving means ineffective for a sufficient time period to permit said pressures to balance.

3. The combination of claim 2 in which said unloader means comprises a small bore tube connecting said condenser to said evaporator.

4. The method of operating a refrigerating system having a compressor, evaporator, condenser, a reversing valve for controlling flow of refrigerant between the compressor and the evaporator and the condenser, and means for equalizing the refrigerant pressures across said valve which method comprises the steps of maintaining said valve in a normal position for permitting said compressor to withdraw refrigerant from said evaporator and to discharge the withdrawn refrigerant into said condenser, of operating said compressor with said valve in said normal position to cool said evaporator, of discontinuing said compressor operation for a time interval sufficient to permit said equalizing means to equalize the pressures across said reversing valve, of reversing said reversing valve to reverse the direction of fluid flow whereby said flow is from said compressor to said evaporator, said reversing of said valve occurring during the period in which compressor operation is discontinued, of thereafter operating said compressor with said valve in its reversed position for a predetermined time interval for the purpose of defrosting the evaporator, and of thereafter returning said reversing valve to its said normal position.

5. The method of claim 4 in which the said reversing valve is returned to its normal position during a time period in which said compressor is ineffective and the pressures across said valve means are substantially equalized.

6. In a refrigerating system, an evaporator, a condenser, a motor, a compressor having an input and an output connected to be driven by said motor, a housing enclosing said compressor and said motor, a first small bore conduit connecting said evaporator to said condenser, a second conduit connecting said evaporator to said housing, a valve body within said housing, a third conduit connecting said compressor output to said body, a fourth conduit connecting said compressor inlet to said valve body, a fifth conduit connecting said body to said condenser, said body having a fluid flow means opening into said housing, fluid flow directing means operable in one position to direct fluid flow from said fluid flow means to said fourth conduit and from said third conduit to said fifth conduit and operable in a second position to direct fluid flow from said third conduit to said fluid flow means and from said fifth conduit to said fourth conduit.

7. In a refrigerating system, an evaporator, a condenser, a motor, a compressor having an input and an output connected to said motor, a motor-compressor housing enclosing said compressor and said motor, a first small bore conduit connecting said evaporator to

said condenser, a second conduit connecting said evaporator to said motor-compressor housing, a valve device having a body within said motor-compressor housing, said body comprising an elongated valve housing having a central passageway extending therethrough and opening outwardly through opposite end portions of said valve housing, said valve housing having oppositely facing valve seats in said passageway facing said end portions, plug members carried by said end portions and overlying said passageway openings, said plug members being provided with valve seats facing said first-named seats, said plug members having apertures extending therethrough and opening into said passageway through said plug seats, a valve stem within said passageway, a pair of valve members each having oppositely facing seat engaging surfaces carried by said stem, one of said valve members being located intermediate one of said first-named seats and one of said plug member seats, the other of said valve members being located intermediate the other of said first-named seats and the other of said plug member seats, the relative spacing between said valve members and said seats being such that when said stem is in a first position said one valve member engages said one first-named seat said other valve member engages said other plug member seat and when said stem is in a second position said other valve member engages said other first-named seat said one valve member engages said one plug member seat, and tubular members carried by said stem and journaled within said plug member apertures, said valve housing having a first port opening into said passageway intermediate said first pair of seats and a second port opening into said passageway intermediate said one housing seat and said one plug member seat and a third port opening into said passageway intermediate said other housing seat and said other plug member seat, a third conduit connecting said compressor output to said second port, a fourth conduit connecting said compressor inlet to said third port and a fifth conduit connecting said body to said first port.

8. The combination of claim 7 in which there is provided a timing means actuated as a consequence of the energization of said motor to control the position of said stem.

9. The combination of claim 8 in which said timing means acts to de-energize said motor for a desired time interval to permit movement of said stem from said second to said first position, re-energize said motor for a desired interval to permit fluid to be pumped into said evaporator, and to de-energize said motor for a desired time interval to permit movement of said stem from said first position to said second position.

10. In a refrigerating apparatus, a compressor, an evaporating element, a condensing element, an expansion device, means connecting said compressor, said device and said elements together into a closed refrigerating system whereby heat laden refrigerant is transferred by said compressor from one of said elements to the other of said elements and said expansion device permits flow of refrigerant from said other element to said one element, a reversing valve connected into and forming a part of said system and having a normal operating position in which said compressor is connected to transfer refrigerant from said evaporating element to said condensing element and having a defrosting position in which said compressor is connected to transfer refrigerant from said condensing element to said evaporating element, a sequencing device having a pair of actuators for actuating a valve controller and a compressor controller in sequence, means including said valve controller for controlling the positioning of said reversing valve, means including said compressor controller for rendering said compressor effective and ineffective to transfer refrigerant between said elements, said sequencing device operating said actuators to first actuate said compressor controller to render said compressor ineffective, to there-

after actuate said valve controller to move said reversing valve from its said normal position to its said defrosting position, to thereafter actuate said compressor controller to render said compressor effective, to thereafter actuate said compressor controller to render said compressor ineffective, to thereafter actuate said valve controller to move said reversing valve from its said defrosting position to its said normal position, and to thereafter actuate said compressor controller to render said compressor effective.

11. The combination of claim 10 in which said sequencing device is operated as a function of time and in which said expansion device is a normally open flow restricting device whereby during periods in which said compressor is ineffective said expansion device is effective to equalize the pressures between said elements.

12. In a refrigerating apparatus, an evaporator having a pair of ports, a condenser having a pair of ports, a compressor having an inlet and an outlet, an expansion device connected between one of said ports of said condenser and one of said ports of said evaporator, a normal control for controlling the operation of said compressor, a non-balanced type reversing valve having a normal position and a reversing position, means including said reversing valve for connecting said evaporator and said condenser and said compressor together into a closed system, said valve when in said normal position connecting the other of said ports of said evaporator to said compressor inlet and connecting the other of said ports of said condenser to said compressor outlet whereby said compressor causes refrigerant to flow from said evaporator to said condenser, said valve when in said reversing position acting to reverse the refrigerant flow whereby said compressor causes refrigerant to flow from said condenser to said evaporator, positioning means for actuating said valve between its said positions, a controller for regulating the operation of said compressor, and a timer having a time actuated element for controlling said controller and effective to actuate said controller into a first position to stop operation of said compressor and to thereafter actuate said positioning means to cause said reversing valve to move from its said normal position to its said reversing position, to thereafter actuate said controller to start operation of said compressor whereby said compressor becomes effective to transfer refrigerant, to thereafter actuate said controller to stop operation of said compressor, to thereafter actuate said positioning means to cause said reversing valve to move to its said normal position, and to thereafter actuate said controller to render said compressor responsive to said normal control.

13. In a domestic electric refrigerator, a refrigeration fluid system comprising an evaporator, a condenser, a compressor, valve mechanism and means for equalizing the pressure between said condenser and said evaporator during periods in which said compressor is not being driven, means for driving said compressor, said valve mechanism having a normal refrigerating position in which it connects said compressor to pump fluid from said evaporator to said condenser and having an evaporator defrosting position in which it connects said compressor to pump fluid from said condenser to said evaporator, a force exerting actuator for exerting a force to urge said valve to its said defrosting position, a compressor control device for rendering said compressor driving means effective and ineffective to drive said compressor, a valve control device for actuating said valve actuator whereby said actuator is effective to exert a force in a direction to move said valve from said normal position to said defrosting position, means actuating said control devices to provide for operation of said control devices in a desired sequence, said sequence including a first interval in which said compressor control device maintains driving means ineffective to drive said compressor and maintains said valve control device

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effective to exert its said force for urging said valve mechanism to said defrosting position whereby said valve mechanism will move to said defrosting position during the time said driving means is ineffective to drive said compressor, said sequence further including a second interval following said first interval in which said valve control device is ineffective to urge said valve mechanisms to said normal position and said compressor control device is actuated to establish operation of said compressor.

14. In a domestic electric refrigerator, a refrigeration fluid system comprising an evaporator, a condenser, a compressor, valve mechanism and means for equalizing the pressure between said condenser and said evaporator during periods in which said compressor is not being driven, means for driving said compressor, said valve mechanism having a normal refrigerating position in which it connects said compressor to pump fluid from said evaporator to said condenser and having an evaporator defrosting position which it connects said compressor to pump fluid from said condenser to said evaporator, an actuator for urging said valve between its said positions, said valve mechanism including elements responsive to the differential in pressure between said evaporator and said condenser, said elements being effective to prevent movement of said valve by said valve actuator when the pressure differential between said evaporator and said condenser is above a predetermined magnitude, a compressor control device for rendering said compressor driving means effective and ineffective to drive said compressor, a valve control device for actuating said valve actuator whereby said valve is urged in a direction to move from said normal position to said defrosting position, means actuating said control devices to provide for operation of said control devices in a desired sequence, said sequence including a first interval in which said compressor control device maintains said compressor ineffective to establish said predetermined magnitude of pressure difference and said valve control device is maintained effective to urge said valve mechanism to said defrosting position whereby said valve mechanism moves to said defrosting position during a period in which said pressure difference is below said predetermined magnitude, said sequence further including a second interval following said first interval in which said valve control device continues to be effective to urge said valve mechanisms to said defrosting position and said compressor control device is actuated to establish operation of said compressor.

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15. The method of defrosting an evaporative type refrigerating system having an evaporator portion, a condenser portion, a fluid pump, conduit means connecting said portions and said pump into a closed system in which said pump transfers fluid between said portions, a reversing valve in said system for selecting the one of said portions to which said pump delivers fluid, and an automatic element for controlling the operating periods of said fluid pump, said method comprising the steps of interrupting the operation of the pump during a time interval in which the automatic element is attempting to maintain the pump operating, of maintaining said interruption for a time interval sufficient to permit an equalization of pressures across the reversing valve, of shifting the valve during the period of equalized pressures, of thereafter returning the control of the fluid pump to the automatic element for a predetermined defrosting time interval in which heat extracted from the condenser is supplied to the evaporator for defrosting the evaporator, and of thereafter shifting the valve to its normal position to permit the fluid pump to remove heat from the evaporator to the condenser under control of the automatic element.

16. The method of claim 15 which includes the subsequent steps of interrupting the operation of the pump at the end of said defrosting interval for a time interval sufficient to permit an equalization of pressure across the reversing valve prior to the shifting of the valve to its normal position, and the step of returning the control of the pump to the automatic element subsequent to the step of returning the valve to its normal position.

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