March 16, 1954 G. MUFFLY 2,672,016

ICE-MAKING AND REFRIGERATING SYSTEM

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FIG. 2.

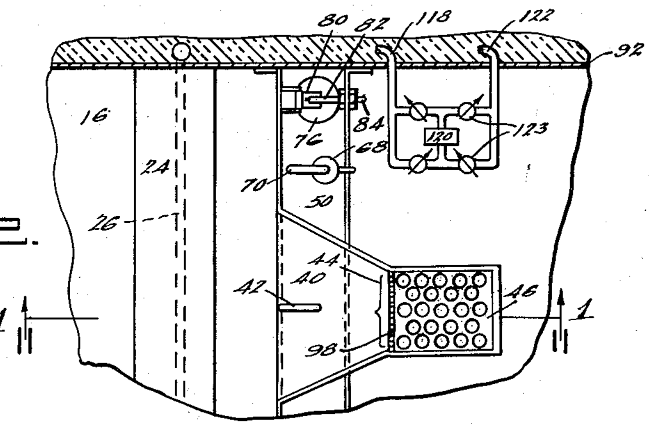
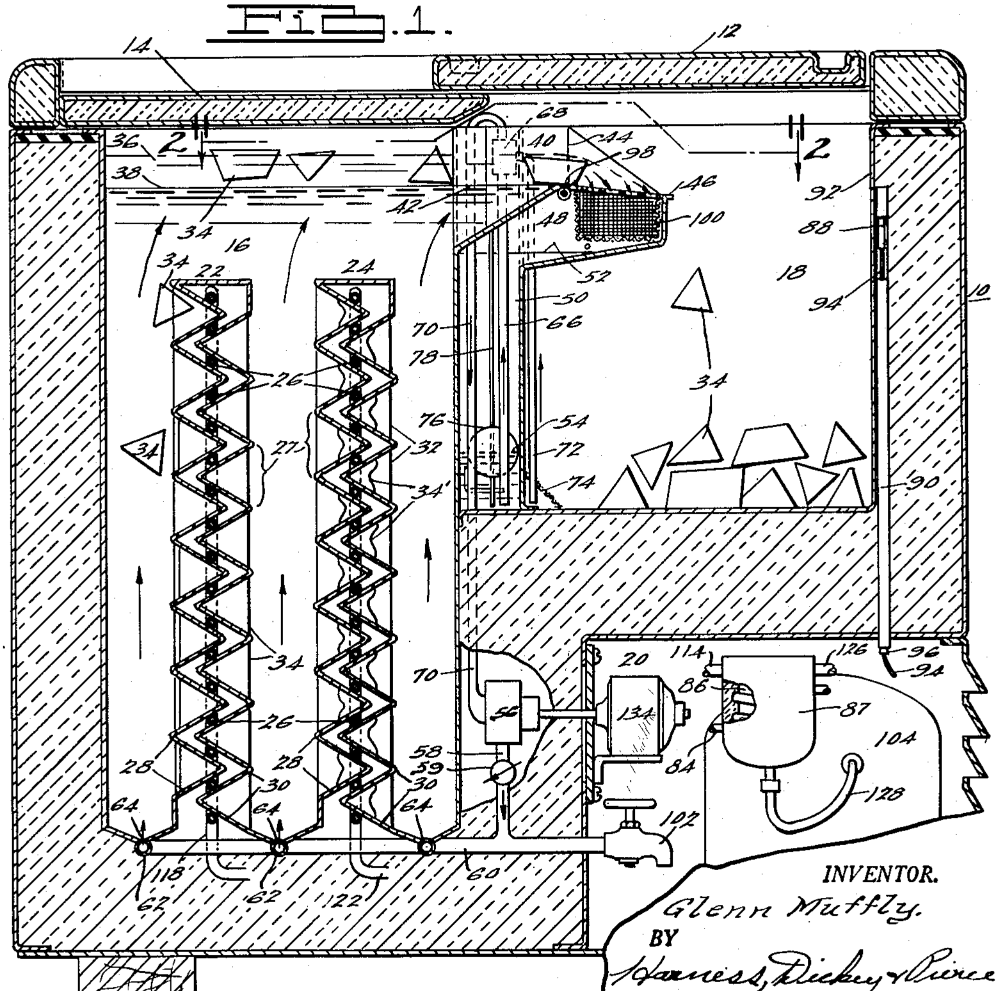


FIG. 1.



INVENTOR.

Glenn Muffly.

BY

Harness, Dickey & Pierce

ATTORNEYS.

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ICE-MAKING AND REFRIGERATING SYSTEM

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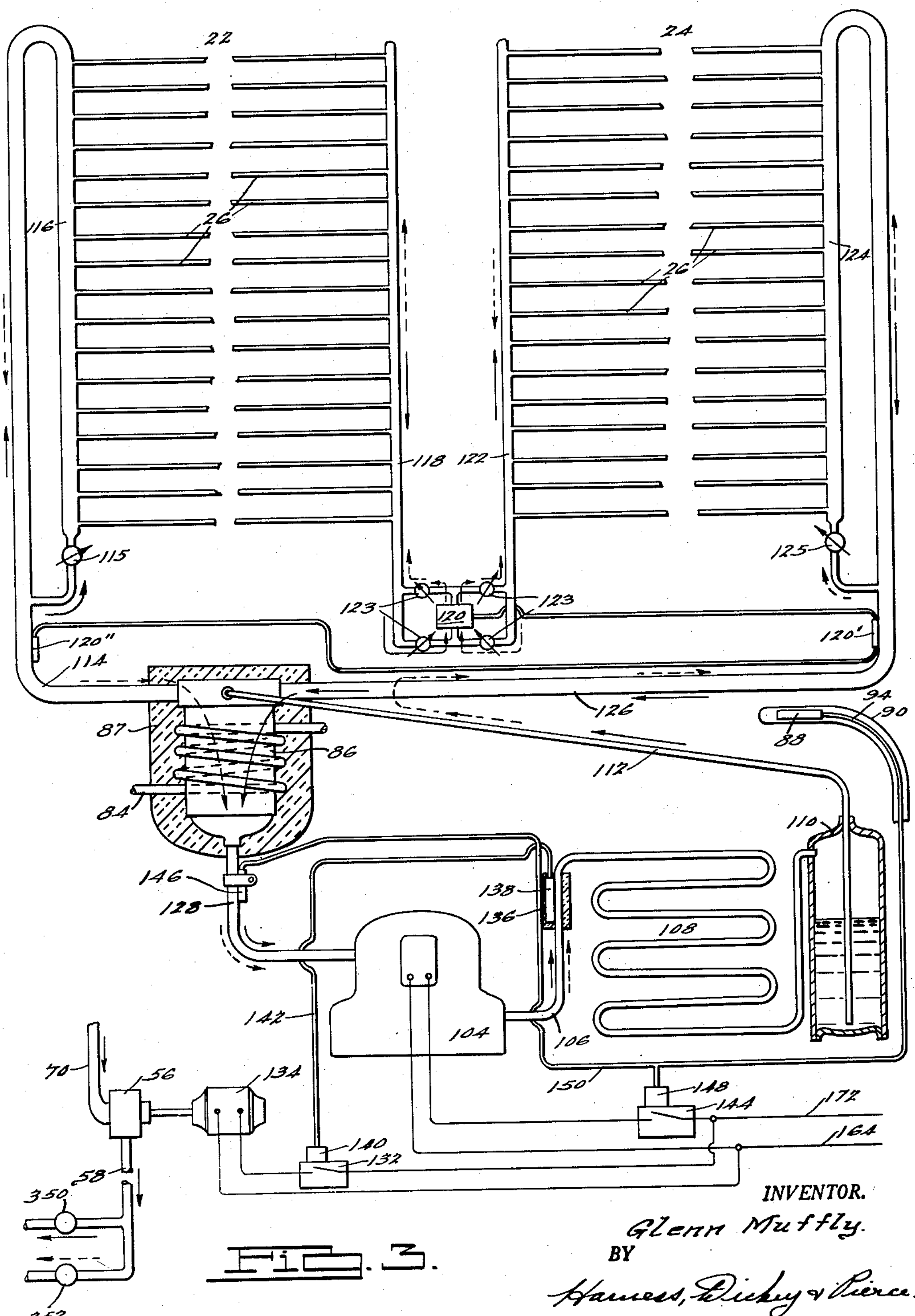

FIG. 3.

INVENTOR.
Glenn Muffly.
BY
Harness, Dickey & Pierce.
ATTORNEYS.

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FIG. 4.

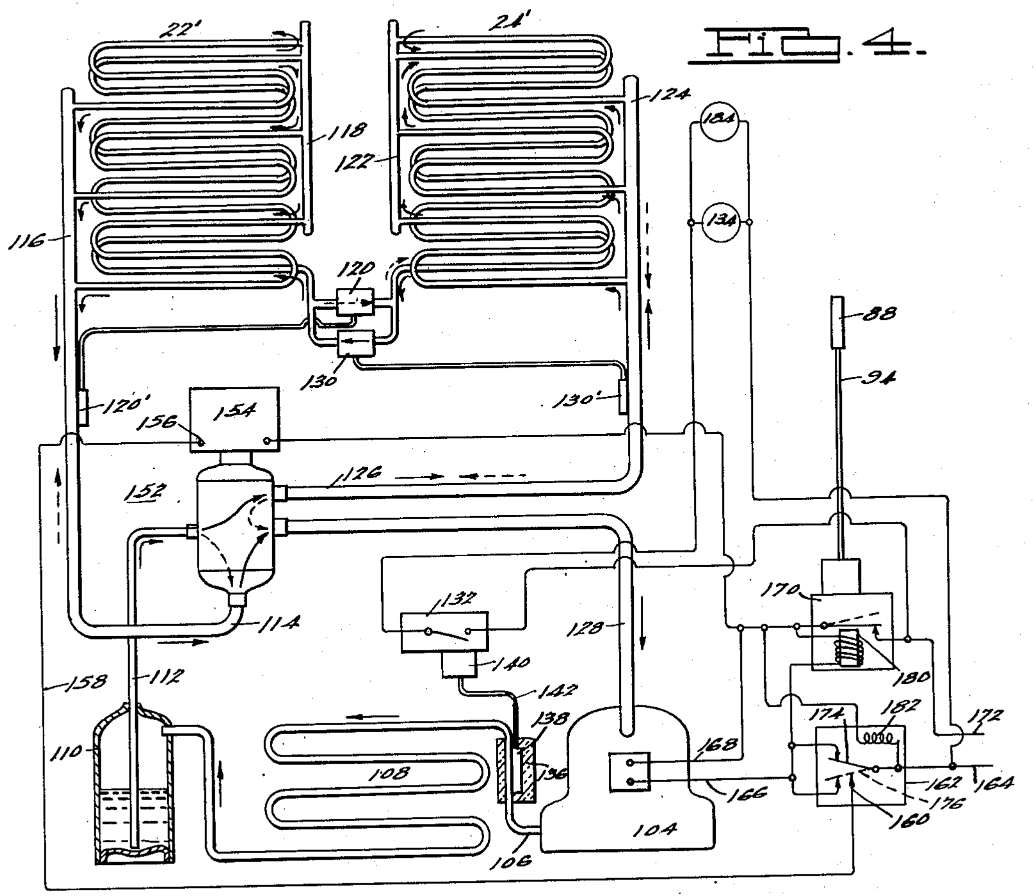
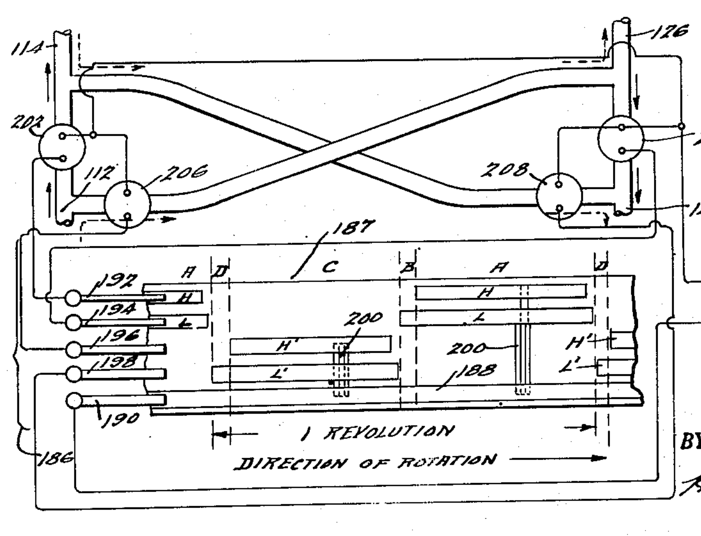


FIG. 5.



INVENTOR.

Glenn Muffly,

BY

Harness, Dickey & Pierce

ATTORNEYS.

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ICE-MAKING AND REFRIGERATING SYSTEM

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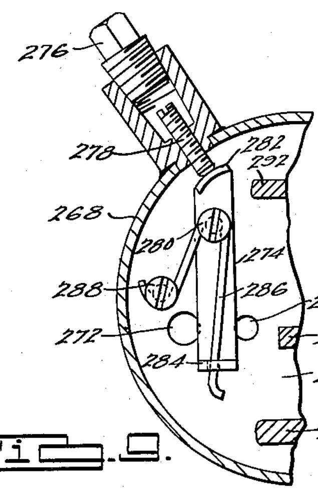

Fig. 9.

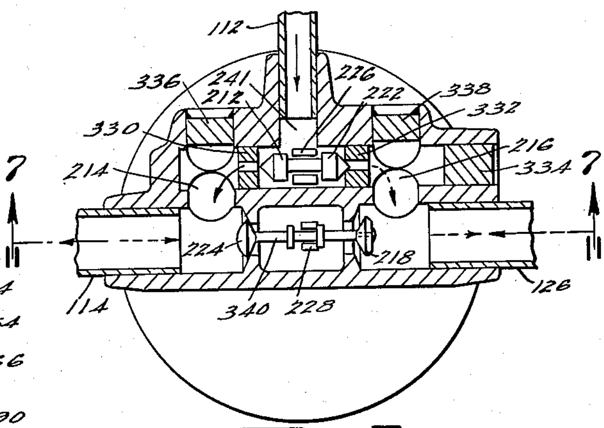

Fig. 6.

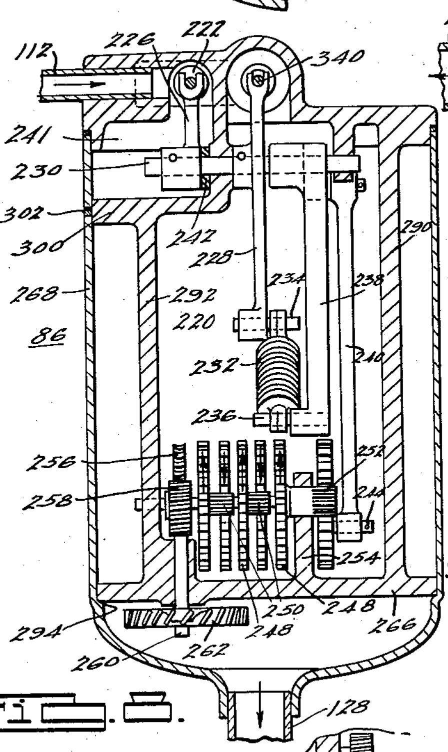

Fig. 8.

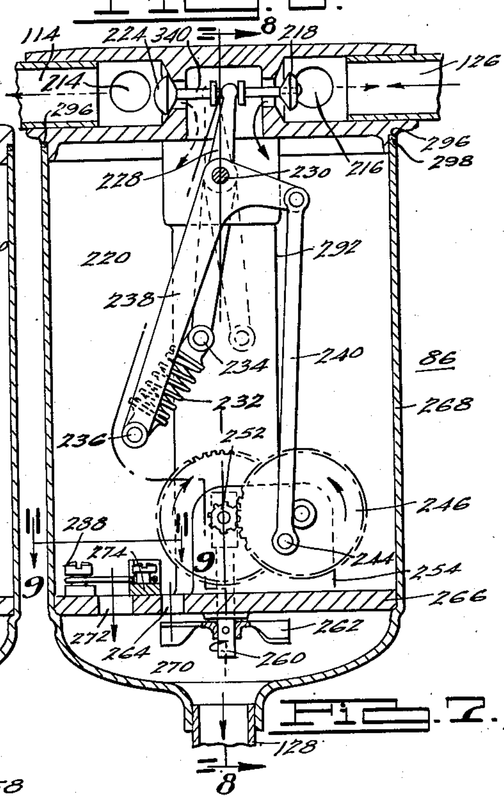

Fig. 7.

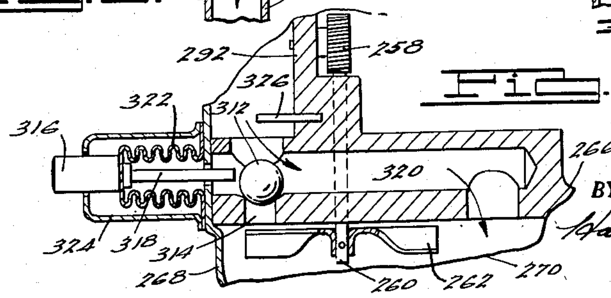

Fig. 10.

INVENTOR.
Glenn Muffly.
BY
Harness, Dickey & Pierce
ATTORNEYS.

Patented Mar. 16, 1954

2,672,016

UNITED STATES PATENT OFFICE

2,672,016

ICE-MAKING AND REFRIGERATING SYSTEM

Glenn Muffly, Springfield, Ohio

Application September 20, 1948, Serial No. 50,101

18 Claims. (Cl. 62—4)

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This invention applies to the fields of ice making and refrigerating systems, and particularly to systems in which refrigerant flow is shifted or reversed so that certain heat exchangers are used part of the time for cooling or ice-making and part of the time for heating. Several issued patents and copending applications of mine are mentioned herein to clarify the specification without repeating the details of these other applications.

Among the many objects of this invention I mention the following:

To provide for separation of ice from water so that the ice may be stored separately.

To provide a control for stopping the refrigerating system in response to the accumulation of a supply of ice in the ice storage compartment and to synchronize this stopping of the system with the ending of one of the shorter cycles of ice freezing, so as to avoid the production of incompletely formed pieces of ice.

To provide a quadruple valve mechanism for control of both liquid refrigerant and refrigerant vapor in the reversible type of refrigerating system employed in the present process of ice making.

To provide means for adjusting the cyclic operation of the above mentioned valve mechanism to obtain longer or short cycles and to provide manual control for running prolonged cycles with either direction of flow.

To supply such a valve mechanism with energy obtained from refrigerant flow and to selectively by-pass more or less of the refrigerant and thereby vary the length of the cycle of valve operation.

To provide for operation of an ice-making system including a tank equipped with means for maintaining a fixed water level while the system is idle and a higher water level while the system is operating.

To utilize the higher water level maintained during operation of the system to produce a flow of water sufficient to carry floating pieces of ice from the ice-making tank.

To maintain the overflow of water from the ice-making tank after the ice-making system has stopped so that pieces of ice last frozen will be transferred to the dry storage compartment.

To provide an overflow tank to accommodate the excess water represented by the difference between the two water levels in the ice-making tank.

To provide a float-controlled water inlet valve responsive to the water level in the overflow tank only during periods of operation.

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To provide means for removing water of meltage from the ice storage compartment and returning it to the ice-making tank, wihch has a higher water level.

To provide control means for starting the ice-making system in response to a reduction in the quantity of stored ice and influenced by higher ambient temperatures to hasten such starting.

To provide more effective agitation of water in the ice-making tank and means for draining impurities from the bottom of the tank.

To utilize the water agitating means to provide energy for removing ice blocks from the ice-making tank and separating them from the water.

To provide an ice delivery chute for removal of floating ice from the ice-making tank and to equip this chute with means for orienting the floating pieces of ice so as to avoid the formation of a jam which might block the overflow passage.

To provide ice pockets or molds in opposite sides of a vertically disposed evaporator assembly.

To provide an arrangement of ice molds in nested back-to-back relationship with evaporator means between them in heat exchange with both sets of molds.

To provide a simplified form of multiple switch actuated by a clock mechanism.

To provide a thermostatic switch with magnetic means for maintaining the switch in its closed position and means for de-energizing the magnetic means at predetermined intervals so that the thermostatic switch is allowed to open only at such times.

To provide a refrigerating system with an auxiliary motor or motors and switch means for starting them after the system has started and for stopping them with a considerable time delay after the stopping of the system.

To provide a clock-operated switch and means for stopping the clock coincidentally with the opening of the switch so that an operating period of the system always comprises a whole number of complete ice-making cycles.

To arrange a single expansion valve so that refrigerant continues to flow thru it in the same direction when the direction of refrigerant flow thru the system is reversed.

To provide a thermostatic expansion valve with two bulbs or thermostatic members so that the superheat is regulated at one time by the temperature of one tube with which one of the bulbs makes contact and at another time by the temperature of another tube with which the other bulb makes contact.

To employ a single expansion valve in a reversible refrigerating system with an arrangement of check valves such that refrigerant flows in one direction thru the expansion valve for both directions of refrigerant circulation in the system.

To arrange an evaporator coil relative to a plurality of ice molds so that each mold is cooled by two sections of the evaporator with these sections arranged in counterflow relationship to each other.

To utilize the heat absorbing capacity of a drier coil connected in the suction line to precool water for later use in making ice.

To provide means for adjusting the length of cycles of the refrigerant reversing valve assembly from the outside of the system.

To provide an arrangement of cabinet and system whereby the ice storage compartment is most accessible and the working parts of the system are readily accessible, at the same time conserving floor space and the volume of space occupied by the complete cabinet and system.

To provide a thermostatic control mechanism which is readily removable and is at the same time adjustable to regulate the height of the main ice supply at which the ice-making system is stopped.

In the drawings:

Figure 1 is an elevation in section showing the cabinet, parts of the ice-making system and parts of the refrigerating system and taken substantially along the line 1—1 of Fig. 2.

Figure 2 is a broken sectional view of a portion of Figure 1 taken on the line 2—2 thereof.

Figure 3 is a diagram of the complete refrigerating system as used in Figure 1.

Figure 4 is a diagrammatic illustration of the complete refrigerating system showing certain modifications from Figure 3.

Figure 5 is a diagrammatic showing of an arrangement of solenoid valves and their control adapted to fit into either Figure 3 or Figure 4.

Figure 6 is a sectional view of the refrigerant flow reversing valves of the valve mechanism 86 seen in Figures 1 and 3.

Figure 7 is a vertical sectional view of the valve assembly showing the operating mechanism for the valves and taken substantially along the line 7—7 of Figure 6.

Figure 8 is a vertical sectional view of Figure 7 showing more of the apparatus for actuating the valves and taken substantially along the line 8—8 of Figure 7.

Figure 9 is a horizontal sectional view of a portion of Figure 7 showing the vapor by-pass valve used for regulating the timing of the valve mechanism and taken substantially along the line 9—9 of Figure 7.

Figure 10 is a modification of the by-pass valve seen in Figure 9.

In Figure 1 we see a sectional side view of the cabinet 10 which has a front sliding cover 12 and a rear removable cover 14. Normally there is no occasion for the user to have access to the ice making tank or compartment 16, as he merely slides the cover 12 back to remove ice from the storage compartment 18, but both covers are removable so that access may be had to the entire interior. The condensing unit is located in a non-insulated compartment 20 and it is connected with the two evaporators 22 and 24, the detail connections being shown in Figure 3.

Continuing with Figure 1 each evaporator 22 and 24 is seen to be arranged so that its horizontal tubes 26 make thermal contact with the molds or cups 27 formed by the two sheets 28 and 30 which are nested in reverse, that is, with their back sides together. The evaporator tubes 26 each make contact with two of these molds except for the uppermost and the lowermost tubes, each of which contacts a single mold or row of molds. Ice can be formed in long bars, but it is proposed to use dividers 32 so that each trough is divided into several molds to form pieces of ice 34, which are say 3″ in length. These blocks of ice form on both sides of each evaporator and later are released to float in the water which during operation of the system fills the tank 16 to the overflowing level 36. When the system is idle the water level stands at 38, as will hereinafter be explained.

The two evaporators are alternately refrigerated by evaporation of cold, low-pressure liquid refrigerant and heated by means of warm, high-pressure liquid refrigerant, one evaporator producing ice while the other is being heated to release ice previously formed. In Figure 1 the left-hand evaporator 22 is filled with warm liquid refrigerant, causing ice blocks 34 to melt loose and float upwardly as indicated while ice is being formed by the right-hand evaporator 24.

As the ice blocks, now at exactly 32° F. so they cannot freeze together, float to the surface of the water, which stands at its overflow level 36 since the system is operating, they float to the right along with the flow of water toward the overflow chute 40. This chute has a vertical post 42 in the middle of its inlet to turn ice blocks endwise as they enter, and a restricted outlet at 44 so that the depth of water thru this outlet for a given rate of water circulation is sufficient to carry floating pieces of ice thru the outlet onto the wire or perforated metal cover 46 of the water return passage 48. The outlet 44 may be V-shaped for triangular bars of ice so that a piece of ice nearly blocking it causes the water level to rise and float the ice thru. The inclination, area and area of openings of 46 are such that substantially all of the water flow goes to tank 50 which extends the full width of the main tank, dividing it from the ice storage compartment 18.

The overflow tank 50 is of sufficient capacity so that when the system stops operating the excess water in the ice-making tank 16 will drain into the overflow tank, establishing a lower level 38 in the main tank and a higher level 52 in the overflow tank. This higher level in the overflow tank is lower than the lower level in the main tank but higher than the operating level 54 in the overflow tank. During operation of the system the pump 56 draws water from the overflow tank and delivers it thru its discharge tube 58 and check valve 59 to the manifold header 60 which has several branches 62 each provided with a number of outlets 64 thru which water is discharged into the bottom of the ice making tank 16. This flow of water is sufficient to wash air bubbles from the newly forming ice and to carry the floating ice blocks thru the chute to a point at which they will fall into the storage chamber 18.

Water is withdrawn from the overflow tank thru the tube 66 which is open at its lower end. The water flows upwardly thru the venturi 68 and then downwardly thru the pipe 70 to the inlet of the water pump 56. The purpose of the venturi is to produce a suction on the tube 72 which is open at its lower end near the bottom of the ice storage tank 18. The section port of the venturi forms the outlet of the tube 72 and is restricted so that the rate of return water flow thru it is very low. A screen 74 protects the inlet of the pipe 72 so that dirt cannot enter to clog the small suction port of the venturi.

The reason for using a small port is that even with this restriction the tube 72 will be passing air instead of water most of the time and the rate of air entry to the venturi must be small enough so that the pump continues to draw water from the overflow tank and deliver it to the various outlets 64. A quantity of air will be circulated with this water to aid in the agitation which causes the ice to freeze in clear form and it also aids in raising the water level so that the ice blocks float from the tank 16. At the time the system steps the tube 72 will be full of air, which serves to break any syphoning effect from the main tank to the overflow tank and to the ice storage space. Even if such syphoning did occur the equalizing of water levels would soon stop it and no damage would be done, as no additional water would be admitted to either tank from the supply line.

During operation the water level in the overflow tank will be at approximately the level 54, but after some of the water has been formed into ice and the ice moved into the storage tank 18 the water level of both the main tank and the overflow tank will fall somewhat. The reduction of water quantity in the overflow tank, which occurs only while the system is operating, allows the float 76 to drop, carrying with it the rod 78 which actuates the bell crank 80 which in turn depresses the stem of valve 82 to allow water to flow from the water suply line 84 into the overflow tank. This water inlet valve is located in the upper part of the overflow tank at about the level of the overflow chute so that the valve is accessible for replacement or for adjustment to raise or lower the water level at which the valve is opened. The water supply line 84 is preferably cooled by heat exchange with the main suction line or valve body 86, as indicated in Figure 3. Insulation 87 is used to reduce heat transfer to incoming water or cold vapor and from warm liquid refrigerant wherever required.

Refrigerant flow is periodically shifted by the valve mechanism 86, which will be more fully described in connection with later views. After all of the ice blocks have floated free from the molds associated with the left-hand evaporator 22 and full-sized ice blocks have formed in the molds cooled by the right-hand evaporator 24 the operations of these evaporators will be reversed so that the left-hand evaporator 22 is refrigerated while the right-hand evaporator 24 is heated by warm liquid refrigerant to release the ice blocks from the molds associated therewith.

This operation continues with ice being formed by one evaporator while it is being thawed free by the other until the accumulation of ice in the storage chamber 18 builds up to approximately the level of the control bulb 88. When this control bulb is cooled to nearly the 32° ice temperature the system will stop at the next shift from one evaporator to the other, the control being so arranged that the compressor is not stopped in the middle of an ice-forming cycle. This provides for finishing whatever freezing cycle is in process at the time the ice supply in tank 18 reaches the level of the control bulb 88, so as to avoid the release of thin shells or partially formed blocks of ice such as 34' in Figure 1.

The control bulb 88 is located within the tube 90 which has good thermal contact with the metal lining 92 of the ice storage compartment. A smaller tube 94 connects the bulb 88 with the control apparatus, as will be explained in connection with Figure 3. This location of the control bulb is such that it can be removed readily as disclosed in my copending Patent S. N. 771,181, filed August 29, 1947, now Patent No. 2,641,109. The tube 90 is of large enough inside diameter to allow removal of the bulb and it is sealed to the smaller tube at its open end as by a split rubber plug 96.

The perforated portion 46 of the ice delivery chute is hinged at 98 to allow access to the overflow passage 48 so that the pan-shaped screen 100 can be removed for cleaning. This screen is to trap foreign matter which may have gotten into the water so as to keep it from entering the pump suction tube 66.

The drain cock 102 may be connected with the water delivery manifold as shown or may be separately connected with each section of the tank 16.

Its purpose is to facilitate drainage of the tank 16 when required. Such drainage is advisable periodically, the frequency depending upon the hardness of the supply water. This method of freezing ice produces ice which is purer than the water from which it is formed, thus resulting in a concentration of minerals in the remaining water and a mineral deposit at the bottom of the tank, hence the need for occasionally draining at least some of the water from the tank to remove the accumulated minerals.

The pipe connections of the refrigerating system are not shown in Figures 1 and 2 but are shown diagrammatically in Figure 3, which illustrates the refrigerating system employed in Figure 1. The solid arrows of Figure 3 indicate the path of refrigerant flow corresponding to the conditions seen in Figure 1, where the left-hand evaporator 22 is being heated with hot liquid refrigerant and the right-hand evaporator 24 is being cooled by evaporation of this same refrigerant. This control of cycling from right to left is produced by the valve mechanism 86, which will be described in more detail later, but for the present its effect will be understood by tracing the paths indicated by arrows. The path of refrigerant flow with the valve mechanism set to refrigerate the right-hand evaporator is as follows, starting with the motor-compressor unit 104.

High pressure refrigerant vapor leaving the compressor thru the discharge tube 106 goes to the condenser 108 where it is changed to its liquid phase and the liquid is delivered to the receiver 110. Warm high pressure refrigerant liquid leaves the receiver thru the tube 112 and passes thru the valve mechanism 86 to the tube 114 leading to the by-pass check valve 115 and to the opposite end of manifold 116 of the evaporator 22. Since the liquid refrigerant is introduced to the evaporator under high pressure it does not evaporate but heats the evaporator to cause the release of ice from the left-hand section. The high pressure liquid-refrigerant, having been cooled by giving up much of its specific heat to the ice being thawed free, now flows from header 118 thru the expansion valve 120 (which is shown as being of the thermostatic type and having two bulbs 120' and 120'') into the liquid header 122 and tubes 26 of the evaporator 24 where it evaporates. The four check valves 123 are so arranged that liquid cannot by-pass the expansion valve and flow directly from 118 to 122. Vaporized refrigerant cannot flow from manifold 124 thru check valve 125, but does flow into the tube 126 which leads back to the valve mechanism 86, now set for conducting this suction vapor from the tube 126 into the suction tube 128 leading back to the compressor.

This operation continues until such time as the valve mechanism operates to change the path of refrigerant flow to that indicated by the dotted arrows in Figure 3. The flow remains the same from the compressor thru the condenser, the receiver and the tube 112 but at the valve mechanism 86 the warm liquid refrigerant entering from the tube 112 is directed into the tube 126 which carries it to the manifold 124 of the evaporator 24, which is now being heated by the warm liquid refrigerant to release ice. The refrigerant is still liquid as it enters the manifold 122 and flows thru the expansion valve 120, but it has been cooled by the heat transfer from it to the ice being released.

Flow thru expansion valve 120 of Figure 3 is in the same direction as before, but the check valves 123 now direct the flow so that it is from 122 to 118. As this cold high pressure liquid refrigerant flows thru the expansion valve 120 its pressure is reduced so that it evaporates in the evaporator 22 and the resulting vapor flows thru the tube 114 to the valve mechanism 86 which directs the suction vapor into the suction tube 128. The manifolds 118 and 122 always carry liquid for either cycle of operation, hence it is permissible to use restricting orifices between them and the horizontal tubes 26 to equalize flow into the tubes 26 of the active evaporator.

The expansion valve arrangement of Figure 4 is also usable in Figure 3 and vice-versa. The Figure 3 arrangement eliminates the expansion valve 130 of Figure 4 but requires the check valves 123. A convenient location for the expansion valve or valves is near the top of the ice storage compartment as indicated at 120 in Figure 2. This conserves cooling effect and is convenient for service.

Soon after the system is started the discharge tube 106 rises to a temperature which causes the switch 132 to close, starting the motor 134 of water pump 56. This delay in starting the water pump lightens the starting load of the system and provides some delay in stopping the water pump after the compressor has been stopped. This operation of the water pump after the compressor stops is to complete the delivery of ice to the storage compartment though it is not essential that all of the ice be so delivered before the water pump stops.

By providing some insulation 136 around the bulb 138 and a portion of the tube 106 the length of time during which the pump operates after the compressor has stopped will be increased and the length of time between the starting of the compressor and the starting of the water pump will be reduced. Since the bulb temperatures at which it is desired to close and reopen the switch 132 are higher than ambient the thermostatic switch 132 will employ a liquid charge and operate on liquid expansion or it will operate on vapor pressure of liquid in the bulb 138 while the bellows chamber 140 and the tube 142 are filled with liquid.

The thermostatic switch 144 which controls the motor-compressor unit is connected with the bulb 88 which is seen in Figure 1 near the upper level to which ice can accumulate in the tank 18. The height of this bulb relative to the ice storage compartment may be adjusted by movement within the outer tube 90.

If this were the only bulb connected with the switch 144 it is seen that operation of the system will continue until the ice level in the storage chamber builds up to about the level of the bulb, but this would result in stopping the system in response to the dropping of ice blocks into the storage chamber regardless of the position in the cycle of ice making. The chances are that such stoppage would occur with ice blocks partly formed on one side, as shown in Figure 1, and with some ice still to be freed from the other set of molds.

The partially formed ice blocks would melt free of themselves during a prolonged idle period and if the period were greatly prolonged they would melt entirely before the next start of the system, but the system would start with its control (the valve mechanism 86) in the middle of a cycle so that the first batch of ice formed would consist of partially formed blocks somewhat as shown attached to the right-hand molds in Figure 1. In order to prevent this starting and stopping midway of ice formation the thermostatic switch 144 is connected with two bulbs, the second one 146 being clamped to the suction tube 128. These bulbs 88 and 146 are in open communication with each other and with the bellows chamber 148 of the switch 144 thru tubes 94 and 150.

The proper operation of switch 144 requires a charge of volatile fluid such that the liquid portion thereof is somewhat more than enough to fill the bulb 88 and the portion of the tube 94 which is within the upper portion of tube 90 soldered or otherwise held in intimate thermal contact with the wall 92 of tank 18. The excess of liquid beyond this will collect in the next colder part of the thermostatic system, which is the bulb 146, because of its association with the suction tube. The point at which the bulb 146 is clamped to the suction tube is within the condensing unit compartment 20 of the cabinet and near enough to the compressor so that this portion of the suction tube is not normally frosted.

There is, however, a periodic frosting of the suction tube each time the valve mechanism 86 operates to reverse the flow of refrigerant thru the evaporators, since this connects an evaporator which is full of liquid with the suction side of the compressor. This might damage the compressor if the suction tube led directly to the compressor cylinder, but it is here assumed that the suction tube leads to the casing of the sealed unit 104 so that a slight flow of liquid refrigerant to the unit casing does not damage the compressor. This momentary frostback does, however, cool the bulb 146 to a temperature lower than the cutout temperature of the switch 144 and liquid will collect in the bulb 146 until this bulb is full, leaving only vapor in the balance of the control except that the bulb 88 will contain some liquid and some vapor. Under this condition, while the bulb 146 is momentarily cooled, the switch 144 is responsive to the temperature of the bulb 88 and if this temperature is at the required cutout point of say 33° F. the switch 144 will open and stop the compressor.

It will be seen that the compressor will not be stopped by the cooling of bulb 146 alone, no matter how cold that bulb gets, neither will it be stopped by the cooling of bulb 88 alone to 33° or colder, but when bulb 88 has been cooled to the cutout temperature of the switch 144, which may be 33° F., the switch will open the next time the bulb 146 is cooled to some temperature lower than the cutout point. After the system is thus stopped all of the volatile liquid of this control will collect in the bulb 88 which is the coldest zone and in the next coldest zone which is that part of tube 94 within tube 90. Warming of bulb 88 due to ice removal or meltage will restart the system. Extra high room temperature causing heat leakage to the bulb 88 and to the tube 94 will hasten the starting, thus providing a quicker start when the demand for ice is most apt to be heavy. In order to allow some greater tolerance on the quantity of the volatile charge of switch 144 the tube 94 may be made somewhat larger than is usual in thermostatic controls, thus allowing plenty of room for all of the liquid part of the charge.

Figure 4 is similar to Figure 3 but shows some modifications including the substitution of a solenoid-operated valve mechanism 152 for the valve mechanism 86 of Figure 3, where valves are actuated by mechanical power derived from the refrigerant flow of vapor. The valve mechanism 152 of Figure 4 is described in detail in my copending application S. N. 45,343 filed August 20, 1948.

As shown in Figure 4 the coil of solenoid 154 is not energized since its terminal 156 connects thru the wire 158 to the open terminal 160 of clock-actuated switch 162. The motor-compressor unit 104 is shown as energized by flow of current thru the line conductor 164 and thru switch 162 to motor lead 166. The other conductor 168 connected with the compressor motor is connected thru the closed switch 170 to the opposite line conductor 172. The valve mechanism 152 is assumed to be in the position causing flow to follow the solid arrows, which in this case indicate defrosting of the right-hand evaporator 24′ and cooling of the left-hand evaporator 22′.

When solenoid 154 is energized this valve mechanism will shift to the position in which refrigerant flow follows the dotted arrows, thus defrosting the left-hand evaporator and cooling the right-hand evaporator in accordance with the operation first described in connection with Figure 3. The control bulb 88 is assumed to be located as seen in Figures 1 and 3 but the switch 170 has no second bulb as does the switch 144 of Figure 3. Instead of the two-bulb method of causing switch 144 to open only at the moment of a shift in the ice-making cycle this effect is attained in switch 170 of Figure 4 by a different method.

The switch 162 has two positions, the one shown by full line 174 and the one indicated by the dotted line 176. In either of these positions the compressor motor is energized and the coil of magnet 180 is energized, but only in the dotted position 176 is the solenoid 154 energized. The purpose of the magnet 180 is to hold the switch 170 closed after the bulb 88 has been cooled to the cutout temperature of say 33° by the accumulation of ice in the storage chamber 18, thus the system will continue to operate after the ice quantity has built up to the cutout point until the next time that the switch 162 is operated.

When switch 162 operates in either direction the circuit thru the winding of the magnet 180 is momentarily open and at this time the thermostatic switch 170 will open if its bulb 88 has previously been cooled to the cut-out temperature. Since the opening of switch 170 opens the circuits of the magnet 180, the clock motor winding 182, the winding of solenoid 154 and of the motor compressor unit 104, the entire system will stop with the exception of the motors 134 and 184 which are controlled by the thermostatic switch 132. The clock motor winding 182 will remain idle so that at the next reclosing of the switch 170 the clock motor starts at the beginning of an ice-making cycle on one or the other of the two evaporators.

The switch 132 is arranged to control the pump motor 134 in the same manner as Figure 3. It also controls the motor 184, which may operate a fan in the event that the condenser 108 is air cooled or it may operate an ice elevator for taking ice from the surface of the water in the ice-making tank 16 and delivering it to the storage chamber 18 if it is preferred to use such an elevator rather than the means shown in Figure 1 for removing the ice from the water in which it floats when released. The clock-actuated switch 162 is not illustrated in detail in Figure 4, as such switches are well known, but attention is called to the fact that the clock motor is in this case so connected that it stands idle while the compressor is idle, having stopped at the instant that switch 170 opened, but the switch 162 always recloses on the other contact or contacts at such times so that when the switch 170 is again closed by a rise of temperature of the bulb 88 the clock motor restarts, being of a self-starting type, at the beginning of an ice-making period on one or the other of the two evaporators.

It will be seen that the switch 144 of Figure 3 with its two bulbs could be used in the hook-up shown by Figure 4, as there will be the same frostback of the suction tube 128 at the instant of the valve operation to shift from cooling one evaporator to cooling the other, but the valve mechanism of Figure 4, not being self-actuated, requires the solenoid 154 and this solenoid in turn requires a periodically actuated switch such as the clock-driven switch 162. In Figure 4 the clock-actuated switch 162 cooperates with the magnet 180 to cause the switch 170 to open at the desired time.

Figure 5 shows diagrammatically a clock-driven switch 186 of the general type disclosed in my U. S. Patent No. 2,027,192 issued January 7, 1936 wherein Figure 6 shows a terminal brush 150 contacting the motor commutator sleeve 154 which is mounted on the insulating element 155 carried by the clock-driven shaft 155′. In the present case a similar wheel or drum 187 of insulating material carries four arcuate metal contact members, H, L, H′, L′ and a complete circular metal contact member 188. The brush 190 is in constant contact with the circular member 188 while the brushes 192, 194, 196 and 198 are in intermittent contact with the arcuate metal members H, L, H′ and L′ respectively. The connecting wires 200 lie partly or wholly buried within the drum 187, at least enough to prevent the brushes 196 and 198 contacting one of them.

When the contact brush 192 is in contact with the arcuate member H the solenoid valve 202 is energized to open so that high pressure refrigerant flows thru the tube 112 to the tube 114. Also when the brush 194 contacts the arcuate member L the solenoid valve 204 is opened for refrigerant vapor to flow from the tube 126 to the suction tube 128. At this time the solenoid valves 206 and 208 are closed because their corresponding brushes 196 and 198 are in contact with the drum of insulating material 187 instead of with their contact members H' and L'.

It is thus seen that in the position indicated by Figure 5 the left-hand evaporator 22 or 22' is being defrosted and the right-hand evaporator 24 or 24' cooled, applying Figure 5 to either Figure 3 or Figure 4. As the drum continues to rotate to the right as indicated in Figure 5, where the drum 187 is shown in development, it will be seen that the first effect of drum rotation is to cause the brush 192 to break connection with the arcuate contact H, allowing the liquid valve 202 to close while low-side valve 204 remains open for a short time represented by the space B.

During this short interval liquid refrigerant continues to flow from the left-hand evaporator 22 or 22' thru the expansion valve 120 to the active evaporator 24 or 24'. This continues for a minute or two of operation which allows the liquid pressure within the inactive (left side) evaporator to drop to say 35 pounds and then the suction valve 204 closes and brushes 198 and 196 make contacts with L' and H' respectively, in this sequence, thus opening the low-side valve 208 an instant before high-side valve 206 is opened.

After an operating period during which the right-hand evaporator is defrosted and the left-hand evaporator is cooled a similar shift occurs, first shutting valve 206 to stop liquid supply to the right-hand evaporator until it drops to a pressure of say 35#, then closing suction valve 208 and opening the valve 204, and a moment later opening the valve 202 to start refrigeration of the right-hand evaporator while the left-hand evaporator is defrosted by means of warm liquid refrigerant.

The arrangement shown by Figure 5 allows the use of four conventional solenoid valves in place of the valve mechanism 86 of Figure 3 or the valve mechanism 152 of Figure 4. While a valve mechanism which combines four valves in one as per Figure 3 or 4 is preferred, the arrangement shown by Figure 5 allows use at the expense of greater cost and a more complicated electrical system of stock solenoid valves. Other valves adaptable for use in this system are shown by Figure 9 of my issued Patent No. 2,145,773, by Figures 1, 6 and 28 of my issued Patent No. 2,145,774, by the drawing of my Patent No. 2,368,675 and by Figure 1 of my Patent No. 2,407,794, but the valve mechanism hereinafter described in connection with Figures 6 to 10 inclusive is preferred because of its simplicity and lower cost.

Figures 6 to 10 inclusive illustrate details of the valve assembly 86 shown in Figures 1 and 3, where the valves are actuated on a timed cycle by the flow of refrigerant vapor. This method of valve actuation is similar to that shown by Figures 9, 10 and 11 of my issued Patent No. 2,359,780 and claimed by the pending division of that patent application Serial No. 621,241 filed October 9, 1945.

The valve mechanism here shown is an improvement over my previous disclosures in that it controls both liquid and vapor, is adapted for causing reversal of flow for melting ice free with either hot liquid refrigerant or hot vapor, is suitable for use in the reversible heat pump type of system and is adjustable from the outside to vary the length of cycle or to stop the cycling for continuous operation with either desired direction of flow.

Referring to Figure 6, hot liquid refrigerant (as in a liquid-defrost ice maker) or high pressure refrigerant vapor (as in a reversible heat pump system) enters thru the tube 112, flows past the open valve 212 into passage 214 and exits thru the tube 114 to the evaporator which is being defrosted to release ice in an ice-making system or to the heat exchanger serving as the condenser in a reversible heat pump system. Suction vapor enters thru the tube 126 to the passage 216 and flows past the open valve 218 to the interior of the main suction chamber 220 (Figure 7) and exists thru the tube 128 to the suction side of the compressor. It will be noted that high pressure valve 222 and low pressure valve 224 are closed and that each of these valves is held closed by high pressure refrigerant which urges each valve in its closing direction against the lower pressure of suction vapor.

Each of these closed valve is rigidly joined with one of the open valves and both pairs of valves are operable by means of levers 226 and 228 which have forked ends embracing the stems of the paired valves in a manner to bear against shoulders on the valve stems to move the valves. These forked ends fit loosely between their respective shoulders as it is desirable to have a considerable amount of backlash so that the valve-operating levers 226 and 228 move an appreciable distance before engaging the opposite shoulders to effect reversal of the valves.

In my copending application Serial No. 45,343 filed August 20, 1948, I show an arrangement of valves similar to that seen in Figure 6, but arranged to be operated by a solenoid with a balancing member 118 to equalize the pull of the solenoid on the two pairs of valves. Equivalent balancing means may optionally be included in the valve mechanism here shown, but is not considered necessary because of the fact that each closed valve is urged against its seat by high pressure refrigerant. In the present disclosure one of the forked members will come to rest with spring pressure urging it against the shoulder which holds one of the valves closed. Mechanical inaccuracies unavoidable in production will cause the other forked member to stop short of or lightly contact the shoulder which urges the other closed valve in its closing direction.

As explained above the valves will be held closed by the high pressure liquid or high pressure vapor. Without going to the expense of providing the equalizing mechanism it is possible to insure pressure of each forked member in the direction of closing its respective valve by incorporating a slight flexibility in the mechanism which connects the two forked levers. For instance as seen in Figure 8 the two forked levers 226 and 228 are keyed to the shaft 230, and such flexibility could be incorporated in the levers, in the shaft or in the mounting of the levers on the shaft.

Again referring to Figure 6 it will be seen that when the two forked levers are simultaneously moved to the left valves 222 and 224 will be opened and valves 212 and 218 moved toward their seats. As high pressure valve 212 approaches its seat it acts as a check valve because of the high pressure refrigerant back of it. As suction vapor valve 218 approaches its seat it will also act as a check valve because high pressure valve 222 has been opened and there is now high pressure refrigerant in the chamber 216 urging the valve 218 against its seat.

After such actuation of the valve mechanism of Figure 6, moving of four valves to the left, high pressure refrigerant will flow past the valve 222 into the chamber 216 where valve 218 is now closed, hence the high pressure refrigerant will flow out thru the tube 126. At the same time suction vapor entering thru the tube 114 to the passage 214 must flow past the open valve 224 to the chamber 220 and out thru the tube 128 since the valve 212 is closed.

Instead of actuating these valves by means of a solenoid, as described in my above mentioned copending application number S. N. 45,343, the actuation is effected by means of the coil spring 232, which is under compression between the pivot 234 on rocker 228 and the pivot 236 on the longer arm of bell crank 238. In the position shown in Figure 7 the bell crank, which is pivoted upon the shaft 230, has been moved in a clockwise direction by means of the connecting rod 240 until the spring 232 is urging the rocker 228 to move in a counterclockwise direction.

Figure 7 thus represents a position of the mechanism which might be assumed at the instant prior to actuation of the valves by the spring 232. Assuming now that such actuation takes place, the forked end of rocker 228 will move to the left, opening valve 224 and closing valve 218. Since the rocker 228 and lever 226 are both keyed to the shaft 230, a similar movement will be made by the lever 226, thus effecting simultaneous operation of both pairs of valves. It will be seen that shaft 230 (Figure 8) passes thru the wall dividing chambers 220 and 241.

To prevent leakage around this shaft the face of the hub of arm 226 and the face of the wall surrounding the hole on the high pressure side, that is, in chamber 241, are accurately finished to provide a substantially leak-proof contact with each other. If desired a washer of compressible material may be employed between these faces as indicated by 242. The higher pressure always prevailing in chamber 241 ensures that the thrust on shaft 230 will always be to the right to maintain pressure on this washer.

The connecting rod 240 is driven by the pin 244 on the low speed gear 246, which may make one revolution per hour. Assuming that this is the speed of the gear 246 it will be seen that the valves will be snapped from one position to the other at intervals of 30 minutes. In order to drive the gear 246 at such a low speed a train of clock gears is employed comprising a number of driven gear wheels 248 and an equal number of driving pinions 250.

The pinion 252 which drives the last gear 246 differs in being cut on the end of a longer hub member which has an external bearing in the support 254. It is also desirable that this pinion 252 and the last gear 246 be of coarser pitch than the other gears because their very low speed increases the tooth load. The first of the pinions 250 (not seen) is mounted on the hub of the worm gear 256 and drives the first of the gears 248. This worm gear is driven by the single-threaded worm 258, which is preferably one piece with the shaft 260, on the lower end of which is mounted the gas-driven wheel 262.

This gas-driven wheel may operate at 1000 or more revolutions per minute in order to drive the final gear 246 at one revolution per hour. The speed of the gas-driven wheel will depend upon the density and the rate of flow of vapor passing thru the hole 264 in the wall 266, which fits tightly within the casing 268 so that vapor flowing from the chamber 220 to the chamber 270 must pass thru either the hole 264 or hole 272.

In order to adjust the speed of the gas-driven wheel 262 and thereby the timing of the valve mechanism I have provided a shutter 274 which can completely close either the inlet of hole 264 or the inlet of hole 272. It will be obvious that the gear train can be stopped by completely closing the hole 264 or that the speed of operation will be greatly increased by completely closing the by-pass hole 272.

Figure 9 shows the means for adjusting the shutter 274 from the outside of the casing 268. This adjustment is a service operation rather than one to be performed regularly by the user, as the timing of the valves will remain substantially constant in any given installation so long as the same compressor is used carrying susbtantially the same load with the same type of control. Even where a thermostatic expansion valve is used, causing a considerable change of suction vapor density from start to end of a running period, the timing will be substantially constant as to the length of cycle even though the gas-driven wheel 262 operates at a considerably higher R. P. M. during the early part of the cycle than it does during the latter part of the cycle. It may, however, be desired at times to change the operating cycle for some reason such as increasing the size of the ice blocks by lengthening the cycle or reducing their size by shortening the cycle. In such case the plug 276 is removed and the screw 278 adjusted to shift the position of the shutter 274 to cover more of the hole 272 so as to shorten the cycle or to cover more of the hole 264 so as to lengthen the cycle.

It will be seen in Figure 9 that the shutter 274 is pivoted on the wall 266 by means of the screw 280. This shutter has two upturned ends, the curved end 282 serving as contact for the screw 278 while the opposite upturned end 284 is notched to receive and retain one end of the spring 286, which may be a plain hairpin type as shown or may include one or more coils around the screw 280. The opposite end of the spring is anchored on the wall 266 as by the screw 288. If the screw 278 is removed entirely the shutter 274 is stopped by contact with the bearing support 254 before its curved end moves out into contact with the shell 268. This allows for assembly of the shell to the mechanism before the screw 278 is inserted. Since chamber 220 contains only low pressure refrigerant vapor, usually at slightly more than atmospheric pressure, there is very little leakage thru the threads of the screw 278 and this leakage is normally outward.

The screw 278 could be provided with a packed stem or with a bellows seal, but this is not considered necessary since the tapered pipe plug 276 will be in place at all times except while a service adjustment is being made to change the cycle of the system. In the event that this valve mechanism is to be used in a heat pump system, where the user will at times wish to shift the operation from a cooling cycle to a heating cycle or vice versa, the shutter 274 or its equivalent may be operated thru a bellows or diaphragm by manual or thermostatic means, as will be described in connection with Figure 10.

The wall 266 which divides the interior of casing 268 is connected with the valve mechanism by means of the members 290 and 292 which may be part of one casting or forging or may be separate members attached to connect the wall 266 and its mechanism with the valve body which closes the upper end of the casing 268. In these drawings the valve body and the entire frame is shown as cast in one piece and in any event they may be assembled in one piece so that the entire mechanism can be tested before the shell 268 is added.

For test purposes a separate air jet may be used to drive the wheel 262 and suitable connections made for leak-testing of the valves. A scale of comparison can readily be established for equivalents of the air jet to various suction vapor densities and rates of flow to determine the desired factory setting of the shutter 274. After assembly and test of the mechanism the shell 268 is pushed over the wall 266 which is forcibly engaged by the shoulder 294 of the shell before the open end of the shell makes contact with the shoulder 296 on the main valve body. This leaves a small gap 298 which is filled with the silver solder or other material used in hermetically sealing the assembly.

Since it is also required to seal the shell to the wall 300 across the bottom and up the two sides of the chamber 241, I provide several small holes as shown at 302 for introduction of solder or for exit of solder in the event that the solder or spelter is attached to one of the members prior to their assembly. Such attachment might be by means of a groove cut in the contact face of the wall 300.

Figure 10 shows a valve arrangement for use in manual control thru the medium of the gas-driven mechanism. In this case a lesser gear reduction is used, as by merely omitting some of the gears so that the valve shift occurs in a few seconds instead of in several minutes. As seen in Figure 10 the ball check valve 312 normally closes the port 314 so that the gas-driven wheel 262 stands idle. When it is desired to shift from one operating cycle to the other the push button 316 is depressed so that the rod 318 holds the ball 312 off of its seat, closing the by-pass passage 320 instead of the port 314. When the shift occurs it is instantly detectable by sound, by a change in the rhythm of the motor-compressor unit and by temperature changes of the connecting tubes. When this change occurs the user merely releases the button 316 and the ball 312 falls back onto its seat, closing the port 314 and thereby stopping the gear mechanism.

The bellows 322 is protected by the cover 324 to avoid injury. By omitting the button and in place thereof attaching a thermostatic or pressure control tube to the cover 324 the bellows may be actuated by pressure or temperature changes so that cycling becomes automatic. One temperature change lifts the ball 312 from its seat and another releases the pressure within the cover 324 to allow the ball to return to its seat. This can be arranged to effect a long cycle of operation in one manner and a variable cycle of operation in the other. The rod 318 may be arranged so that it does not extend thru the casing 268 except when actuated, or the cover 324 may be made deep enough so that the rod may be retracted for the purpose of assembling the cover over the mechanism. The stop pin 326 is to keep ball 312 from falling out of place.

By combining the bellows 322 of Figure 10 with the shutter 274 of Figure 9 and making the bellows thermally responsive by means of a thermally responsive fluid enclosed between the bellows and its casing 324 a thermostatic control of the speed of the gear train is obtained. Thus a bulb connected by means of a capillary tube with the sealed cover 324 would, when warmed, cause the rod 318 to push against the upturned curved end 282 of shutter 274, as the screw 278 does in Figure 9, causing the shutter to move in the direction of opening port 264 and closing port 272 and thus speed up the gear train to hasten the operation of the valve mechanism. The bulb could be located in contact with the inlet tube of expansion valve 120 in Figure 3, so as to be warmed by a rise of temperature of high pressure liquid refrigerant flowing from either evaporator that is being defrosted.

The effect of this would be to cause or hasten operation of valve mechanism 86 in response to a rise of temperature of the liquid refrigerant that has passed in heat exchange with the molds 27 of the assembly 22 or 24. With such an arrangement the mechanism of 86 would be designed to cause somewhat longer cycles than are necessary to allow time for ice to release, but the cycle would be shortened by a rise of refrigerant liquid temperature at entry to the expansion valve, such rise of temperature being dependent upon the ice blocks having been released.

It is thus seen that the valve mechanism shown by Figures 6 to 10 inclusive may be used in various types of systems for operation under various temperature conditions with various lengths of cycles, with or without thermally actuated control of timing, or for seasonal adjustment to heating or cooling.

The valve seats 330 and 332 are preferably inserted to simplify machining. The valve seat 330 would be pressed into place first, preferably against a slight shoulder provided for that purpose. The part forming the two valves 212 and 222 would then be inserted after which the valve seat 332 is pressed into place to a predetermined position and the plug 334 pressed in and brazed or soldered. The two plugs 336 and 338 are similarly installed if the passages 214 and 216 are drilled. If these passages are in the forging or casting the plugs will not be required. The valve 218 is attached to the stem 340, as by upsetting the stem, while the opposite valve 224 may either be similarly attached or formed of one piece with the stem. At least one of these valves is pushed onto the stem against a shoulder and the stem riveted or spun over to retain the valve.

Water circulation may be stopped in the ice-making tank or a section thereof while its evaporator is being heated to release ice. This conserves some energy and avoids some loss of ice weight. This may be done by stopping the water pump in an ice-maker which freezes ice in all molds at one time, but in a system such as shown by Figure 3 the water circulation is diverted by means of valves 350 and 352, which may be solenoid-operated. Such solenoid valves may be controlled by thermostatic or timed means, for instance the switch shown in Figure 5 might have two extra brushes such as 192 to 198 and corresponding contact members on the drum 187 to open one or the other of the valves. An alternative would be to use two pumps 56 driven by separate motors and employ the switching means to start and stop one motor at a time.

The two pumps may be operated simultaneously for a short period or both valves 350 and 352 be held open for a time to provide periodically an extra flow of water from the tank 16 to clear it of floating ice. Conversely water flow to all outlets 64 may be stopped for a short period to allow warmer water to settle to the bottom of the tank (due to its reverse thermal expansion) and to suspend the forced flow of water so that ice blocks ready to float from molds are allowed to do so freely.

In Figure 1 it may be advisable to place a dividing wall consisting of a single sheet of metal midway between **22** and **24**, which are then spaced farther apart, with separate sets of water jets **64** on opposite sides of the wall to localize the agitation.

The check valves **115** and **125** are connected to allow flow of warm liquid directly to the evaporator tubes associated with any of the molds **27** which are slowest in releasiing ice, thus equalizing the ice-releasing time. These valves allow free flow of liquid for ice releasing but are closed to vapor flow in the opposite direction.

Wherever cold suction vapor flows thru a conduit located in a warm space, such as the condensing unit compartment **20**, it is advisable to insulate such conduits as indicated by **87** in Figure 3. Also it is advisable to insulate any hot liquid conduit exposed to low temperature, such as that of the ice storage compartment **18**. It will therefore be found best to locate the liquid valves **202** and **206** in the condensing unit compartment **20** and to locate suction control valves **204** and **208** in the ice storage compartment **18**, as this reduces the areas requiring separate insulation.

I claim:

1. In an ice-making apparatus, an ice-making chamber, a compartment for storage of small pieces of ice, a pump for providing water agitation for the purpose of producing clear ice, a tube connected with said pump, a venturi connected with said tube, and a second tube leading from a lower portion of said ice storage compartment to the side inlet of said venturi for the purpose of lifting water from the bottom of said storage chamber and delivering it to said ice-making chamber.

2. In a refrigerating system of the reversible type, a pair of heat exchangers arranged to serve alternately as evaporator and condenser, valve means for reversing refrigerant flow, means enclosed within the refrigerant circuit of said system for taking energy from the flow of said refrigerant and applying it to the actuation of said valve means, and means operable from outside of said circuit for controlling the operation of said valve means to effect the reversal of refrigerant flow.

3. In an ice-making apparatus including a refrigerating system for making and releasing individual pieces of ice, a cooling element forming a part of said system, means for storing said ice after its release, transfer means for moving said ice to said storage means, a motor for operating said transfer means, and control means adapted to stop operation of said cooling element to stop the formation of ice and thereafter to stop said motor.

4. In a refrigerating system employing a volatile refrigerant, a pair of evaporators, a plurality of refrigerant conduits connecting said evaporators in said system, a valve for diverting the flow of said refrigerant in its liquid phase relative to at least one of said conduits, a valve for diverting flow of said refrigerant in its vapor phase relative to at least one of said conduits, and a device energized by flow of the vapor of said refrigerant for actuating both of said valves.

5. In an ice-making system, a tank adapted to contain water and small pieces of ice in flotation, overflow chute means for conveying such ice from said tank, and means for orienting such pieces of ice as they enter said chute means to cause them to move endwise therethrough.

6. In an ice-making system, a pair of evaporators connected in series, means for introducing high pressure liquid refrigerant to one of said evaporators to fill it and passing said refrigerant into the other of said evaporators at reduced pressure to cool it, timing means including gears driven by the flow of refrigerant vapor from the evaporator being cooled, and valve means actuated by said timing means to cause a reversal of flow of refrigerant thru said evaporators so that the one which has just finished a cooling period is heated by the introduction of high pressure liquid refrigerant while the evaporator which has just finished a period of being heated by liquid refrigerant receives liquid refrigerant at reduced pressure from the evaporator now being heated and is thus cooled by the evaporation of said refrigerant.

7. In an ice-making system including a water tank, two sets of molds arranged in back-to-back relationship to form a vertical assembly within said water tank, evaporator means included in said assembly and in heat exchange with said molds, and means for causing alternate cooling of said molds by the evaporation of a volatile liquid refrigerant in said evaporator means and heating of said molds by warm high pressure refrigerant passing thru said evaporator means.

8. In an ice-maker, means for employing warm high pressure liquid refrigerant to melt ice free, an expansion device for thereafter reducing the pressure on said refrigerant, means for effecting cyclic operation of said ice-maker, and means responsive to a temperature rise of said liquid at its entry to said pressure reducing device to shorten the cycle of operation then in process.

9. In an ice-making system, an ice-maker tank, an overflow outlet for said tank, a tank arranged to receive overflow water from said outlet and to have a lower water level during operation of said system and a higher water level during idle periods, and a float-actuated valve for supplying make-up water to said system, the float which operates said valve being located in said overflow tank at a level below said higher water level.

10. In a refrigerating system of the reversible heat pump type, a plurality of solenoid valves for reversing refrigerant flow in a part of said system, a multiple switch connected with the solenoids of said valves, and a clock mechanism to operate said switch.

11. A refrigerating system including a compressor and a motor for driving said compressor, a pump driven by an auxiliary motor for circulating fluid to be cooled by said system, a first control means for starting and stopping the first said motor, a second control means arranged to start and stop the second said motor, a thermally affected member forming a part of said second control means and located in heat transfer relationship with a part of said system, and thermal insulating means arranged to protect saio member.

12. In an ice-making system including a refrigerating system employing a volatile refrigerant, means for utilizing the specific heat of a high pressure liquid refrigerant to release ice from surfaces on which it has been formed, means for supplying water to said ice-making system for use in making ice, and means for utilizing the specific heat absorbing capacity of

low pressure refrigerant vapor to precool said water before it is frozen.

13. In an ice-making system, a refrigerating system for cooling said ice-making system, valve means for causing cyclic operation of said ice-making system, said valve means being enclosed within the refrigerant circuit of said refrigerating system, an energy source for actuating said valve means also enclosed within said circuit, and means external to said circuit for adjusting the length of the cycles of operation of said valve means.

14. In a refrigerating system adapted to circulate a volatile refrigerant, means for causing said refrigerant to reverse its direction of circulation in at least a portion of said system, a refrigerant expansion device located between two sections of said portion, and means for causing refrigerant to flow thru said expansion device in the same direction for both directions of refrigerant flow thru said portion of the system.

15. In a refrigerating system adapted to circulate a volatile refrigerant, means for causing said refrigerant to reverse its direction of circulation in at least a portion of said system, a refrigerant expansion device located between two sections of said portion, and check valves arranged to direct refrigerant flow thru said expansion device in the same direction for both directions of refrigerant flow thru said portion of the system.

16. In a refrigerating system, a pair of evaporators, means for causing evaporation of refrigerant in said evaportors one at a time while the other of the evaporators is heated by high pressure refrigerant, an expansion valve of the thermostatic type arranged to regulate flow of liquid refrigerant to whichever one of said evaporators is active as an evaporator, and a pair of thermal response elements connected with said valve to control it, one of said elements being associated with each of said evaporators to cause the valve to respond to changes of operating conditions of the active evaporator.

17. In a refrigerating system including a compressor and employing a volatile refrigerant, valve means for diverting flow of said refrigerant, motor means entirely enclosed within said system and driven by said refrigerant to actuate said valve means at substantially uniform time intervals, and means external to the refrigerant circuit of said system for stopping said motor means while said compressor continues to operate.

18. In a refrigerating system, means for circulating a refrigerant, means within the circuit of said refrigerant for modifying its flow, gear reduction means within said circuit for actuating the second said means, means actuated by the flow of said refrigerant to drive said gear reduction means, and a by-pass valve adjustable from outside of said circuit to vary the speed of said gear reduction means.

GLENN MUFFLY.

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