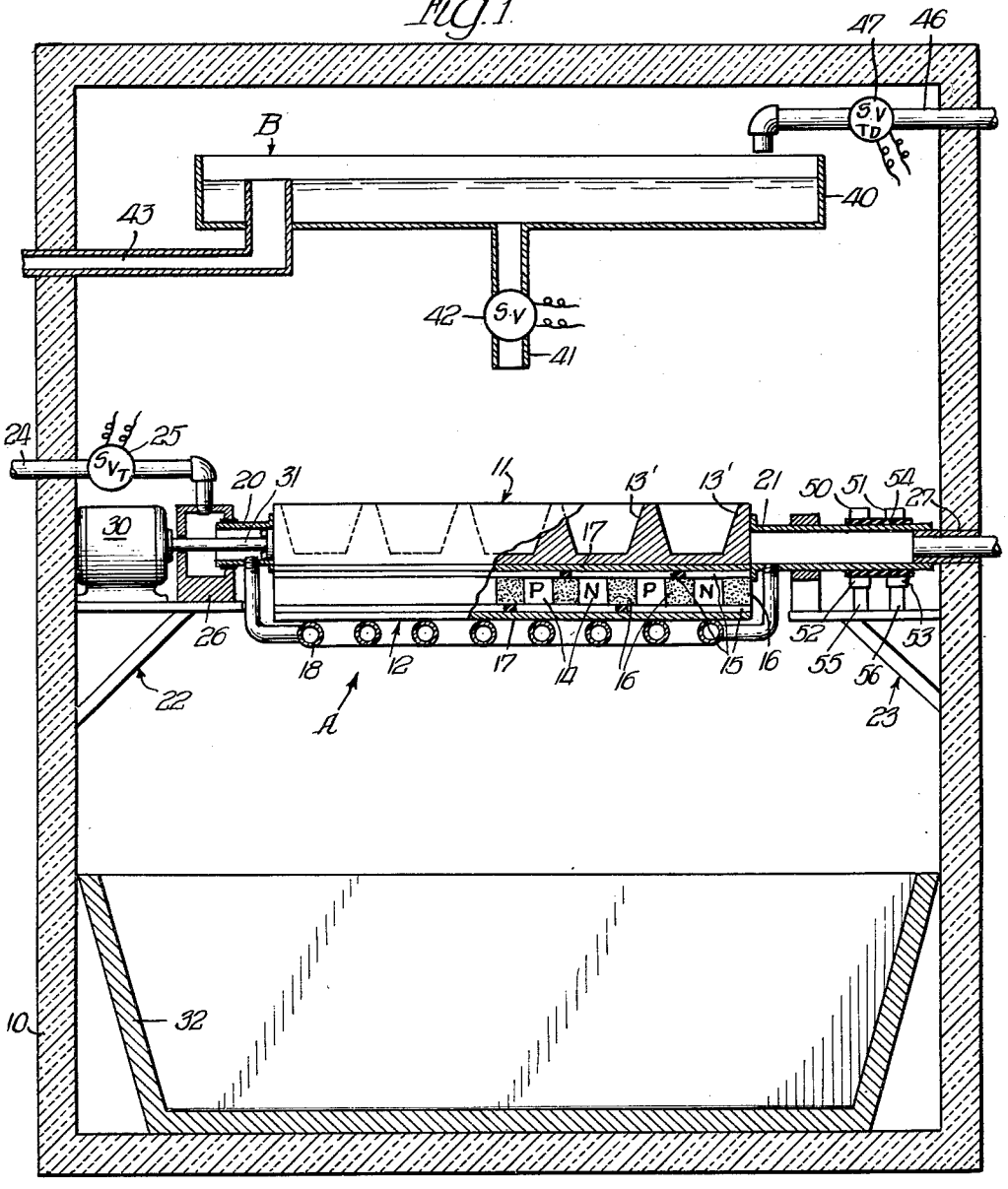
July 6, 1965 A. B. NEWTON 3,192,726

THERMOELECTRIC ICE MAKER

Filed May 22, 1964 2 Sheets-Sheet 1

Fig. 1.



INVENTOR.
Alwin B. Newton,
BY
Thomas B. Hunter
Atty

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Filed May 22, 1964 2 Sheets-Sheet 2

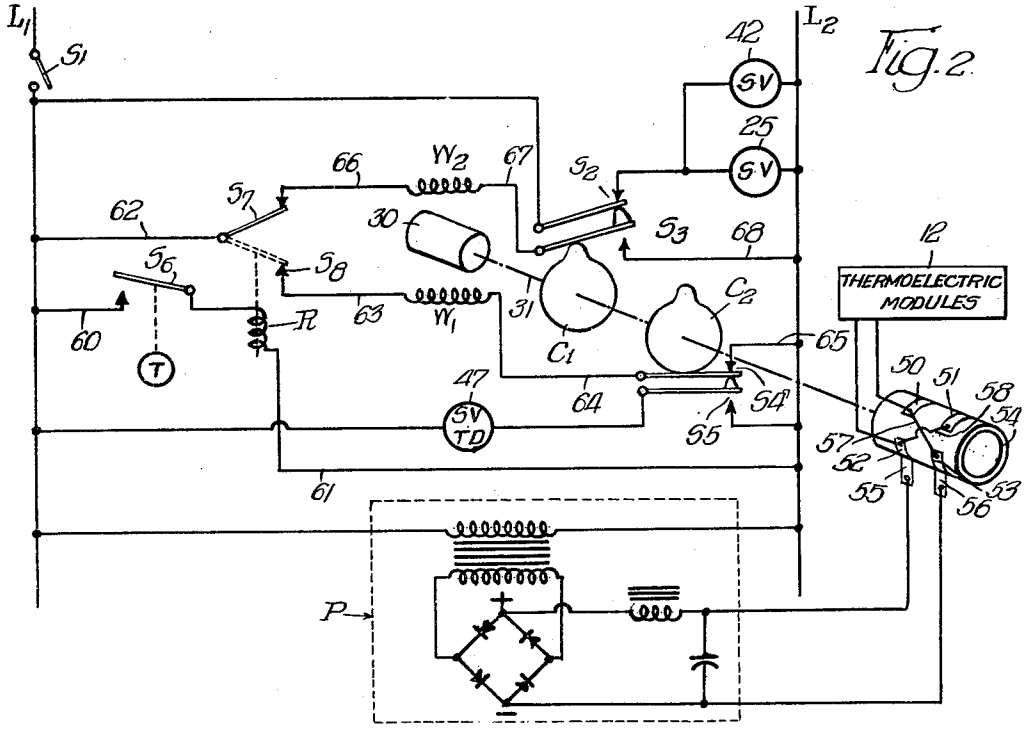


Fig. 2

Fig. 3

		S2	S3	S4	S5	S6	S7	S8	R	W1	W2	VALVE ACTUATING SOLENOIDS 25	42	47	
BEGINNING OF FREEZING CYCLE		X	O	X	O	O	X	O	O	O	O	X	X	O	
END OF FREEZING CYCLE		X	O	X	O	X	O	X	X	X	O	X	X	O	
MOVEMENT FROM FREEZE TO HARVEST POSITION		O	X	X	O	X	O	X	X	X	O	O	O	O	
BEGINNING OF HARVEST CYCLE		O	X	O	X	X	O	X	X	O	O	O	O	X	
END OF HARVESTING CYCLE		O	X	O	X	O	X	O	O	O	X	O	O	O	
MOVEMENT FROM HARVEST TO FREEZE		O	X	X	O	O	X	O	O	O	X	O	O	O	

X= CLOSED OR ENERGIZED
O= OPEN OR DE-ENERGIZED

INVENTOR.
Alwin B. Newton,
BY
Thomas B. Hunter
Attty.

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THERMOELECTRIC ICE MAKER

Alwin B. Newton, York, Pa., assignor to Borg-Warner Corporation, a corporation of Illinois

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11 Claims. (Cl. 62—3)

This invention relates to improvements in thermoelectric ice makers and more particularly to an ice cube maker having means for automatically controlling its operation during all phases of the ice making cycle.

With advancing technology in the art of thermoelectric materials, the use of thermoelectric modules for heating and/or cooling has become more widespread. Thermoelectric devices are now being utilized in many applications where reliability of operation, resistance to vibration, and shock, and small physical dimensions are essential. Moreover, thermoelectric conditioning can be justified in many instances, even where it is somewhat more expensive than using conventional conditioning means, because of many cost offsetting advantages which are impossible to attain by ordinary refrigerating and heating systems.

Briefly described, the present invention comprises a freezing mold in combination with a thermoelectric module assembly and an improved control system for automatically charging water into the mold, freezing it, and transferring the ice from the mold to a storage receptacle.

For purposes of definition, the terms "thermoelectric module" or "thermoelectric assembly or unit" are meant to cover any device employing the Peltier effect for heating or cooling. Since these devices are reversible in the sense that heat can be selectively abstracted and rejected from different sides of the module by merely reversing the direction of current supplied thereto, one side will be referred to as the load side and the opposite side referred to as the sink side. When the devices are used for cooling, heat is pumped from the load side to the sink side where it is dissipated by means of a heat exchange medium, usually air or water; when the device is used as a heating means, heat is pumped from the sink side to the load side.

In a preferred embodiment of the invention described herein, the ice mold is arranged so that it is in optimum thermal contact with the load side of the thermoelectric assembly. During the freezing cycle, current is supplied to the thermoelectric assembly in such a manner that heat is abstracted from the mold to freeze a charge of water therein. During the harvest cycle, the mold is inverted and the direction of current supplied is reversed so that said mold is heated to facilitate the release of the ice from the mold. Actually, the heating may be accomplished by either reversing the D.C. current as stated above or by supplying A.C. current to the modules as described in copending application, Serial No. 225,415 (Breneman), filed on September 19, 1962.

Accordingly, it is a principal object of the invention to provide an improved ice cube maker having a thermoelectric assembly for supplying the required refrigeration necessary to form the ice, and also to supply the heat for assisting in the release of the ice from the mold.

It is another object of the invention to provide an improved control system for automatically programming the freezing and harvesting phases of the ice making cycle.

Additional objects and advantages will be apparent from a reading of the following detailed description, taken in conjunction with the drawings, wherein:

FIGURE 1 is a cross-sectional view, with certain components shown schematically, of an ice maker constructed in accordance with the principles of the present invention;

FIGURE 2 is a schematic diagram showing the circuit for controlling the operation of the ice maker; and

FIGURE 3 is a table which indicates the position or mode of various components in the control circuit.

Referring now to FIGURE 1 of the drawings, reference character A designates the combined freezing mold and thermoelectric assembly which is mounted within an insulated cabinet 10. The combined mold and thermoelectric assembly, hereinafter referred to as the mold assembly, comprises a mold section 11 and a thermoelectric section 12. The mold section, in a preferred embodiment, may be made from a cast block of aluminum or other heat conductive material and is provided with a plurality of open-ended cavities 13 in which the water is frozen. The mold section is affixed to the load side of the thermoelectric section 12 by any suitable means so as to insure optimum heat transfer therebetween.

It will be noted that the construction of the thermoelectric section 12 is more or less conventional in that it includes a plurality of alternating P and N type thermoelectric billets 14 connected in series by conductors 15 in a manner well known to those skilled in the art. The space betwen the billets is commonly filled with an insulating material such as polyurethane foam indicated at 16. Opposite sides of the module sub-assembly are provided with separators or interfaces 17, each of which comprises a material which exhibits good thermal conductivity and poor electrical conductivity to prevent short circuiting of conductors 15. Examples of such materials are described in copending application S.N. 169,805 filed on January 30, 1962. On the sink side of the thermoelectric assembly, means are provided for supplying a heat exchange medium, such as water, for dissipating the heat generated at the hot junction when the device is operating during the freezing cycle. Means for this purpose include a heat exchange tube 18 affixed to the sink side interface and arranged in a serpentine pattern across the entire area thereof.

The entire mold assembly is mounted within the cabinet 10 so that it may pivot around its axis of support on hollow trunnions 20 and 21 which are supported by means of brackets and bearing assemblies 22, 23. The sink side heat exchange medium supplied to the heat exchange tube is connected through these bearing assemblies to a water supply line 24 which may include a solenoid-operated valve 25, said valve being provided for a purpose to be described below. The heat exchange medium thus flows into the left-hand bearing element 26 through the trunnion 20 and passes out through trunnion 21 and a connecting pipe 27 which leads to a drain.

The mold assembly is adapted to be pivoted from its upright freezing position as shown in FIGURE 1 to substantially inverted, harvest position by means of a reversible electric motor 30 which is connected to the mold assembly by means of a shaft 31, said shaft extending through the bearing element 26. When the mold assembly is pivoted to its harvest position, it is positioned directly over a storage receptacle 32 located in the lower portion of the insulated cabinet 10. The storage receptacle may be made removable for convenience in withdrawing the ice cubes from the cabinet.

The water charging system for supplying a controlled quantity of water to the mold cavities 13 to initiate a new freezing cycle is designated generally by reference character B. The charging system comprises a reservoir in the form of a shallow pan 40 located in the upper portion of the cabinet 10, a charging conduit 41 having a solenoid-operated valve 42 connected therein, and an overflow line 43 having an open, upper portion terminating below the upper edge of the pan 40. A water supply line 45 having a solenoid-operated valve 47 provided with time delay means is adapted to supply water to the pan 40 to prepare for the initiation of the freezing cycle.

The operation of valves 42 and 47 will be described with greater detail in connection with the operation of the control system.

Power for the operation of the thermoelectric unit is supplied through contacts 50, 51, 52, and 53 mounted on an insulating sleeve 54 and rotatable with the right-hand supporting trunnion 21. Contacts 50–53 are connected on the one side through conductors (not shown) to conductors 15 which carry the current through the thermoelectric unit and are engageable by stationary brushes 55, 56 mounted on the bracket-bearing assembly 23. The contacts are wired together in such a fashion that the direction of current supplied to the thermoelectric unit when the mold assembly is in its inverted, harvesting position is opposite to the direction of current when the mold assembly is in the upright, freezing position shown in FIGURE 1. This will become clear from the description of the control system which follows.

Referring now to FIGURE 2 of the drawings, the circuit for programming and controlling the operation of the ice maker is shown in schematic form. Electrical energy is supplied to the unit through conductors L1, L2 which may be connected to a 110-volt, 60-cycle A.C. outlet. The main power switch S1 is connected in one of said lines to turn the system on and off. A rectification circuit for converting the A.C. current to D.C. current for the thermoelectric modules is connected across L1, L2 and designated generally at P. The A.C. to D.C. converter is conventional and any suitable design may be employed to provide a substantially ripple-free D.C. current supply for the thermoelectric modules.

It was noted in the description given in connection with FIGURE 1 that one of the trunnions on which the mold assembly is supported carries a sleeve 54 having a plurality of contacts 51–53 mounted thereon which cooperated with a pair of brushes 55, 56 adapted to engage said contacts. As shown in the schematic diagram there is a sleeve 54 carrying contacts 50, 51, 52, and 53 which are engageable by brushes 55, 56. The contacts are connected by conductors 57, 58 for reverse switching of the current flow supplied to the thermoelectric modules indicated at 12. In other words, as the mold assembly and the sleeve 54 rotate 150°–180° from the position shown in FIGURE 2, the direction of current flow (voltage polarity) is reversed.

The electric motor 30 which drives the mold assembly from its freezing position to its substantially inverted, harvest position, and vice versa, is of the reversible type and has associated therewith a pair of windings W1 and W2. When winding W1 is energized, the motor armature and drive shaft 31 are rotated in one direction and when winding W2 is energized, they are rotated in the opposite direction. Shaft 31 carries a pair of cam elements C1 and C2 (not shown in FIGURE 1) which are rotatable therewith and are operable to selectively actuate switches S2, S3, S4, and S5 in a manner to be described below.

A temperature actuated switch is shown at S6, said switch being responsive to the thermostat T which is located adjacent to the mold or in some position to accurately sense the temperature within the mold. Thermostat T may be set to open at 50° F. and close at 0° F. to insure that the ice is completely harvested or frozen, depending on which part of the cycle is in operation. The required setting of the thermostat for any particular unit may vary depending on its location, the size of the mold, etc. Relay R, which is actuated by switch S6, is operatively connected to switches S7 and S8, which may be combined in a single SPDT switch mechanism. Switches S7 and S8 selectively actuate windings W1 and W2 to control movement of the mold assembly between its freezing and harvesting positions.

To facilitate an understanding of the sequence of operations, it will be convenient to refer to FIGURE 3 which indicates the position or mode of the switches, solenoids,

and other elements in the circuit. It should be pointed out that the legend used to denote the condition of the switches, etc., insofar as it refers to valves 25, 42, and 47, indicates the energization or non-energization of the solenoids for actuating said valves and not to the position of the flow controlling element. In other words, when the condition of solenoid valve 42, for example, is designated by the letter X, this means that the solenoid is energized and the valve open. When the condition is designated by O, this means that the solenoid is de-energized and the valve is closed. FIGURE 2 illustrates the positions of each circuit component after the mold assembly has returned to its freezing position, and been charged with water to begin the freezing phase of the cycle. Thermostat T, which opened at approximately 50° F. to terminate the harvesting phase, is still open and relay R remains de-energized so that S7 is closed and S8 is open. Since cam C1 is in a position whereby switch S3 is open, no current is supplied to winding W2. D.C. current is being supplied to the thermoelectric assembly in the cooling mode so that as freezing continues, the temperature within the mold slowly drops until thermostat T closes S6 at approximately 0° F. When T closes switch S6, relay R is energized through conductors 60 and 61. Switch S7 is opened and S8 closed, as indicated by the dotted line position, so that winding W1 is energized through conductors 62, 63, 64, closed switch S4 and conductor 65. The motor then drives the mold assembly from its freezing position toward an inverted position. When the mold assembly has rotated 150° to 180°, cam C2 opens switch S4 to de-energize winding W1 and stop further rotation of the mold assembly. Immediately after the mold assembly begins rotation to its harvesting position, the movement of cam C1 closes switch S3 and opens switch S2. Since S7 is open, winding W2 cannot be energized, but with the opening of S2, both solenoid valves 25 and 42 (time-delay) are de-energized and therefore, closed.

At the same time switch S4 is opened, C2 closes switch S5 to energize solenoid valve 47 which begins filling the reservoir 40. Solenoid valve 47 is open for only sufficient time to fill the reservoir pan 40. This solenoid valve is of a type which has a time delay feature with automatic re-set. When energized, the valve stays open for long enough to fill the pan, then shuts off and resets itself to repeat this operation when energized again. Such valves are commercially available so no detailed description is required for purposes of this disclosure. With solenoid valve 42 closed, flow through the charging conduit 41 is prevented while the pan 40 is being filled (initiated by the closing of S5 at the end of the transition from freezing to harvesting). When valve 25 is closed, the flow of water through the sink coil 18 is shut off during the ice harvesting phase. Valve 25 is an optional feature and may be dispensed with in many types of installation. Moreover, with regard to the means for cooling the sink side of the thermoelectric assembly, it should be understood that rather than using water, the sink side can be cooled by air or some other heat exchange medium. If cooled by ambient air, fins or other means for promoting heat transfer can be mounted on the sink side in place of tube 18, and a fan or other air moving device can be associated therewith to flow air over the fins. The solenoid valve 25 may then be replaced by a switch for the fan motor so that the fan operates to remove heat during the freezing cycle and is turned off during the harvesting cycle.

During the ice harvesting cycle, current is being supplied so that the load side, that is the side adjacent to the mold, is heated to facilitate removal of the ice cubes from the mold. When the cubes are released from the mold and fall into the storage receptacle, the temperature of the mold rises rapidly to open thermostat T (at approximately 50° F.) and deenergizes relay R. When

relay R is de-energized, switch S8 opens and S7 closes to energize winding W2 through conductors 62, 66, 67, closed switch S3 and conductor 68.

As the motor drives the mold assembly in the reverse direction back to its freezing position, cam C1 eventually reaches the point where it opens switch S3 to de-energize winding W2 and stop the motor. At the same time, switch S2 is closed actuating solenoid valves 25 and 42. This begins the flow of water to the sink heat exchange coil and permits the water to drain from pan 40 to charge the cavities 13.

While this invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of this invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

What is claimed is:

1. Ice making apparatus comprising a pivoted mold having a cavity therein; a thermoelectric module carried by said mold, said module having a sink side and a load side, said load side being in thermal communication with said cavity; means to pivot said mold to thereby invert said cavity; a thermostat carried by said mold and in thermal communication with said cavity, said thermostat controlling the operation of said means for pivoting the mold; and means for changing the direction of current through said thermoelectric module upon pivoting of said mold whereby upon heating the cavity, ice within the cavity will be discharged therefrom.

2. Apparatus as defined in claim 1 including means to return said mold to its original position upon the attainment of a predetermined temperature of the cavity; and means to fill said cavity with water upon its return to said original position.

3. Apparatus as defined in claim 2 including means to dissipate heat generated at the sink side of said thermoelectric module.

4. Ice making apparatus comprising a mold assembly including an ice mold and a thermoelectric unit in heat exchange relation therewith, said ice mold having a plurality of cavities therein adapted to be charged with water, said thermoelectric unit being associated with said mold to abstract heat therefrom during a freezing cycle and to heat said mold during a harvesting cycle; power supply means adapted to supply D.C. current to said thermoelectric unit; means for mounting said mold assembly for pivotal movement from a freezing position to a substantially inverted harvest position; temperature responsive means associated with said ice mold; and means actuated by said temperature responsive means for pivoting said mold assembly from said freezing position to said harvest position.

5. Apparatus as defined in claim 4 including means for reversing the direction of D.C. current supply to said thermoelectric unit upon pivoting of said mold assembly.

6. Apparatus as defined in claim 4 wherein said thermoelectric unit includes a load side and a sink side, said load side being attached directly to said ice mold and pivotable therewith.

7. Apparatus as defined in claim 6 including means for supplying a secondary heat exchange medium to the sink side of said thermoelectric unit.

8. Ice making apparatus comprising a cabinet; a combined mold and thermoelectric assembly pivotally mounted within said cabinet, said mold having a plurality of cavities therein for receiving a charge of water to be frozen; means for supplying a charge of water to said cavities; a bin positioned underneath said mold for receiving and storing ice cubes discharged from said cavities; temperature responsive means associated with said cavities; and means actuated by said temperature responsive means for pivoting said mold to a substantially inverted harvest position when said temperature responsive means indicates that the ice cubes have been completely frozen, said means also adapted to return said assembly to its initial position after said ice cubes have been discharged.

9. Apparatus as defined in claim 8 wherein said means for supplying a charge of water to said cavities includes a water reservoir; means for conducting water from said reservoir to said cavities; valve means associated with said last-named means; and means for opening said valve means each time the mold assembly returns to its freezing position and for closing said valve means after the said charge of water flows into the freezing cavities.

10. Apparatus as defined in claim 9 including means to fill said reservoir with water during the time said valve is closed.

11. Ice making apparatus comprising a mold assembly, said mold assembly including an ice mold having a plurality of open-ended cavities and a thermoelectric unit having a load side and a sink side, said mold being fixed to the load side of said thermoelectric unit; means for mounting said mold assembly for pivotal movement between a freezing position wherein said cavities are oriented in an upright position and a harvest position wherein said cavities are substantially inverted; reversible drive means for pivoting said mold assembly from one position to the other; a power supply for supplying D.C. current to said thermoelectric unit; means for providing a heat exchange medium in thermal relationship with the sink side of said thermoelectric unit; a storage receptacle located below said mold assembly, said storage receptacle adapted to receive ice cubes released from said mold cavities during the harvesting cycle; means for supplying a charge of water to said ice mold when the cavities are oriented in their upright position to initiate the freezing cycle; and means associated with said power supply for reversing the direction of current supplied to said thermoelectric unit each time the mold assembly is moved from its freezing position to its harvesting position or vice versa.

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ROBERT A. O'LEARY, *Primary Examiner.*