April 22, 1952 W. M. GRANDIA 2,593,874

ICE-MAKING

Filed Oct. 29, 1948 3 Sheets-Sheet 1

FIG. 1.

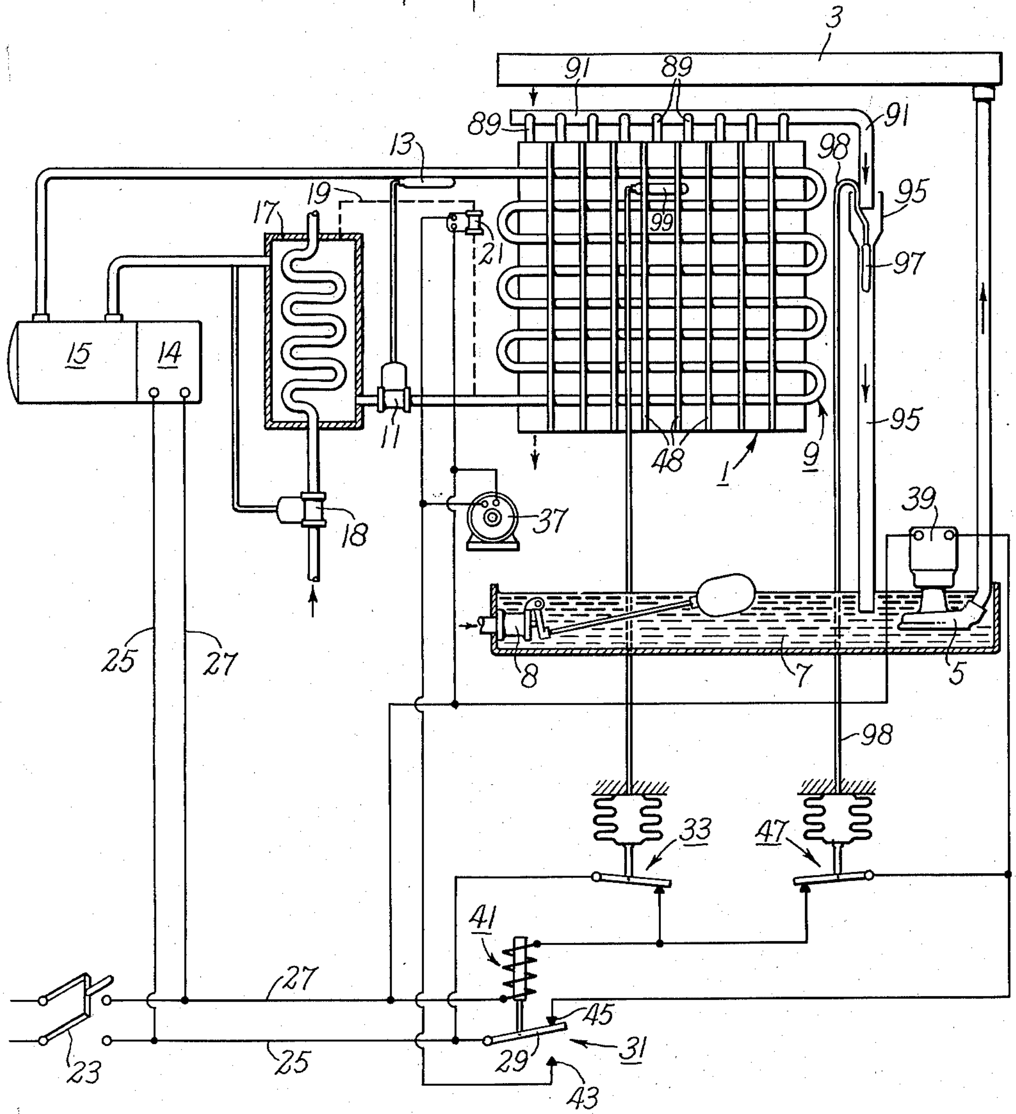

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FIG. 2.

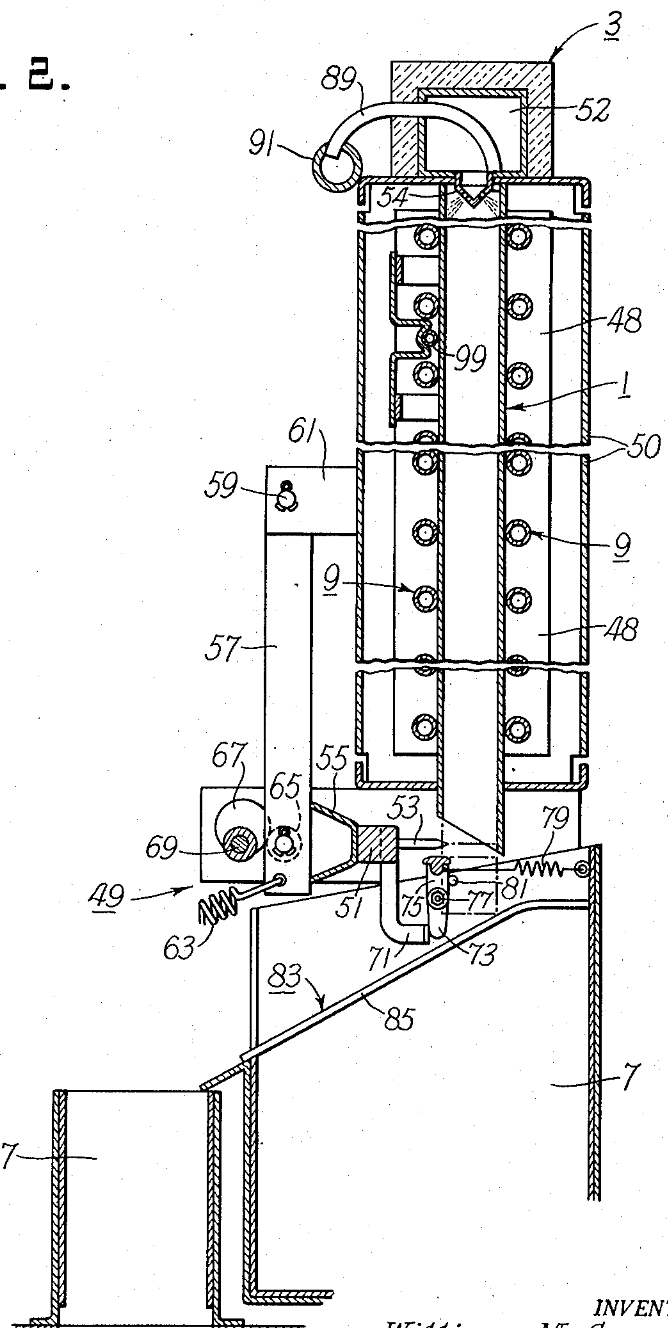

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FIG. 3.

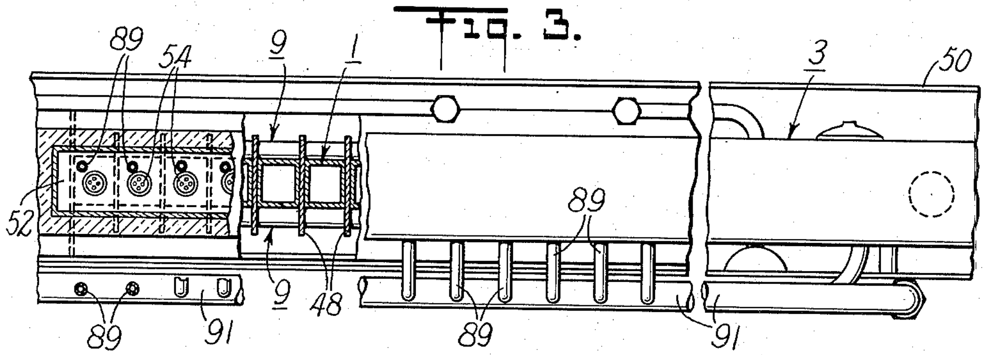


FIG. 4.

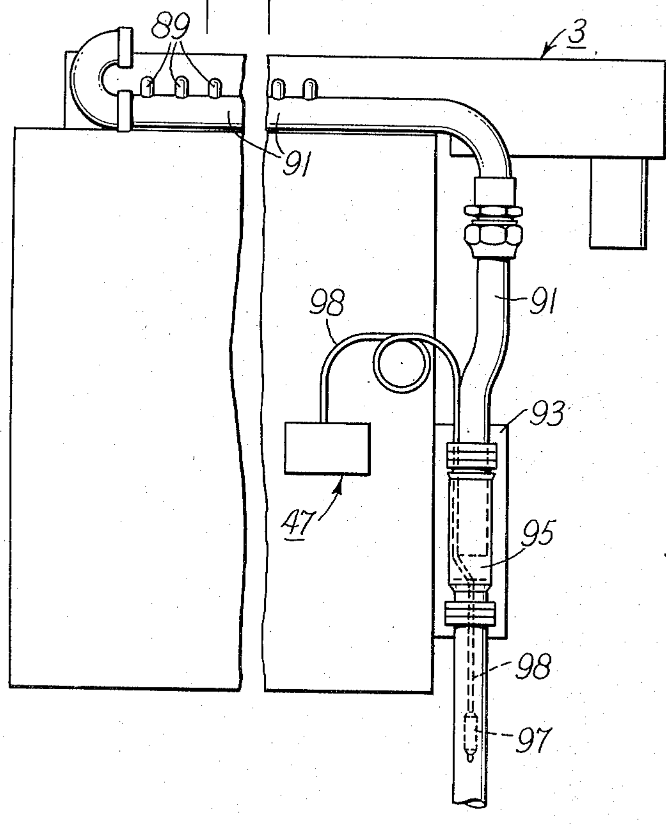
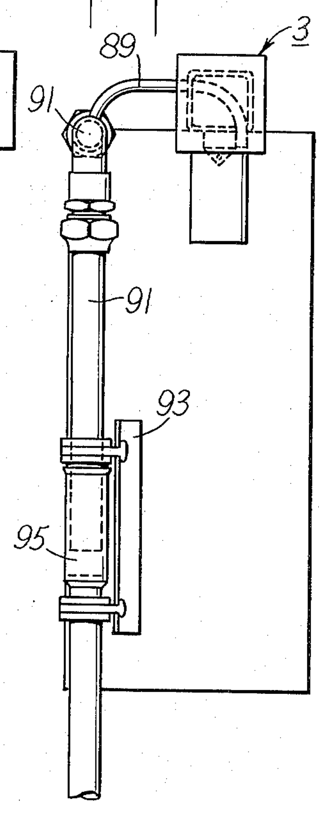


FIG. 5.



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UNITED STATES PATENT OFFICE

2,593,874

ICE-MAKING

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Application October 29, 1948, Serial No. 57,158

13 Claims. (Cl. 62—7)

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This invention relates to refrigeration, and more in particular to the operation and control of machines such as those disclosed in the copending applications of Meldon Gerald Leeson, Serial No. 573,939, filed January 22, 1945 and Serial No. 686,021, filed July 24, 1946. These applications became Patents Nos. 2,524,815 and 2,549,747 on October 10, 1950 and April 17, 1951, respectively.

The above-identified applications disclose machines and methods for making ice, illustratively in the form of cubes which may have cylindrical holes therethrough. The machine of the latter-filed of the above applications will be discussed in general terms, and the illustrative embodiment of the present invention is in the form of such a machine modified only in the manner herein specified. Reference may be had to the above-identified applications for more detailed discussions of certain of the constructions and operations.

In the second-mentioned application referred to above, ice in the form of small cubes is produced by apparatus which operates in two alternate operations or cycles known as the freezing operation or cycle and the harvesting operation or cycle. During the freezing cycle water is circulated by a pump from a sump to a header from which the water flows downwardly on the inner surfaces of a plurality of vertically-positioned square tubes. These tubes are positioned in a bank in side-by-side relationship and on the two sides of the bank there are evaporator sections of a refrigeration system. The refrigeration system is so controlled that the tubes are cooled sufficiently to freeze the water in the tubes and the ice builds up in each tube in the form of a column of clear ice having a hole therethrough. Water is circulated in excess of that which is frozen and the excess water returns to the sump and is recirculated.

When the ice has built up to the thickness desired, the freezing cycle is stopped and the harvesting cycle is started. During the harvesting cycle hot refrigerant gas is passed from the compressor of the refrigeration system into the evaporator sections with the result that the columns of ice are thawed free and they drop from the bottom of the tubes. As the columns of ice emerge from the bottoms of the tubes they are chopped or cut into lengths to form cubes. When the tubes are free of ice the harvesting operation is terminated and the freezing operation is restarted.

With ice making machines of the character referred to above, it has been difficult to control the operation so as to obtain maximum efficiency at all times. For example, if the freezing and harvesting cycles are carried on in accordance with a simple time cycle it is difficult to insure that the ice is frozen to the exact thickness desired, and it is also difficult to insure that the harvesting operation will be completed within a specified time, unless the timing is such as to allow for extreme conditions. For example, when the machine is operated with high ambient temperature the ice freezes very slowly and the harvesting operation is completed rapidly; but when the ambient temperature is low the freezing operation progresses rapidly and the harvesting operation is apt to take an excessive amount of time. If the freezing operation is stopped before the ice builds up to the desired thickness the machine is not operated efficiently, and if the freezing operation is not terminated when the ice reaches the desired thickness there is danger of freezing the ice solid and this may cause damage. Furthermore, if the harvesting operation is discontinued before the tubes are freed of ice there is danger of damaging the tubes during the next freezing operation.

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These conditions are aggravated by the normal variations in the temperature of the water supplied to the machine. For example, if the water is received at a high temperature the freezing rate is slow, whereas if the water is received at a low tmperature the freezing rate is high. It is among the objects of the present invention to provide a method of operation and a control system which will make it possible to freeze ice under varying conditions with maximum efficiency at all times. It is a further object to provide a safety control means which will prevent damage to the machine in case one or more of the freezing tubes becomes "frozen up," i. e., has ice frozen solid therein. Another object of this invention is to provide a simple efficient and thoroughly practical control and mode of operation for apparatus of the character referred to above. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combination of elements, and arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawings in which is shown one illustrative embodiment of the invention:

Figure 1 is a schematic diagram representing an ice making machine of the character referred to above and incorporating the present invention;

Figure 2 is a vertical section of the freezing tube and ice cutting assembly of the machine of Figure 1;

Figure 3 is a top plan view with parts broken away showing the ice freezing tubes and evaporator unit of Figure 2;

Figure 4 is a front elevation of the apparatus of Figure 3; and

Figure 5 is a side elevation from the right-hand side of Figure 4.

Referring to Figure 1 of the drawing there is represented schematically at the top a bank of freezing tubes 1 to the tops of which water is directed by a header 3 supplied by a pump 5 from a sump tank 7. The water flows down the tubes and some is frozen, and the amount in excess of that frozen in the tubes returns to the sump tank. A float valve 8 connected to a source of water opens and closes automatically to maintain a predetermined level in the tank. The freezing tubes are cooled by an evaporator 9 to which liquid refringerant is supplied through a thermostatic valve 11 having a bulb 13. The gas refrigerant from the evaporator is withdrawn by a compressor 15 having an electric motor 14 hermetically sealed within its casing. The compressed gas passes from the compressor 15 to a water-cooled condenser 17 cooled by water supplied through a valve 18. The refrigerant is here liquefied and passes to the exaporator. During the harvesting cycle hot gas refrigerant is passed from the compressor to the evaporator to heat the freezing tubes, accordingly, a pipe 19 (indicated by broken lines) having a normally-closed solenoid valve 21 therein which valve is opened to connect the outlet side of the compressor to the bottom of the evaporator.

Power to operate the machine is supplied through a main control switch 23 to a pair of lines 25 and 27 which are connected directly to the compressor motor. Line 25 is also connected to the armature 29 of a double-throw, solenoid switch 31 and also to one side of a thermostatic switch 33. Line 27 in connected to one side of each of the solenoid valve 21, the ice cutter motor 37 which operates the mechanism to cut the ice into cubes, the water pump motor 39 which drives pump 5, and the solenoid 41 of switch 31. Switch 31 has its normally-closed contact connected to the other side of the solenoid of valve 21 and also to the other side of motor 37; and it has its normally-opened contact 45 connected to the pump motor 39 and also to one side of a thermostatic switch 47. The other side of switch 47 is connected to solenoid 41 and to switch 33. The operation of the machine will be explained after the construction of the freezing tubes and the associated parts have been explained in detail.

Referring to Figures 2 and 3 of the drawings, there is shown the bank of square freezing tubes 1 positioned in side-by-side relationship with a plate 48 between the side walls of each two adjacent tubes. On the opposite sides of the bank of tubes there are two evaporator sections of evaporator 9 formed by horizontal runs of metal tubing with the sections being connected by headers. The bank of freezing tubes and the evaporator sections are covered by insulation and enclosed in a sheet metal casing 50. At the top of the bank of tubes, there is a horizontal water supply header 52 which is enclosed in an insulation shell, and projecting from the bottom wall of this header into the top of each of tubes 1 is a water nozzle 54 which directs four streams of water, respectively, against the inner surfaces of the four walls of its tube.

At the bottom of the freezing tubes there is an ice cutter assembly 49 which includes a horizontal cutter bar 51 which carries a plurality of cutter picks 53 and which is mounted by a bracket 55 on a swinging U-frame 57. Frame 57 hangs with each of its ends swingably mounted on a pin 59 supported by a bracket 61. A spring 63 urges the frame to the left so that each of a pair of rollers 65 carried by the frame is held against an eccentric cam 67 fixed to a rotating shaft 69. Bar 51 carries an arm 71, the lower end of which engages an arm 73 of an ice-holding bar 75. Arm 73 and a similar arm (not shown) are pivoted on the walls of the machine by a pair of pivots 77 so that the ice-holding bar 75 is swingably mounted, and this bar is urged to the right by a spring 79 against a stop 81. Beneath this ice cutter assembly 49 is an inclined grill 83 formed by a large number of parallel spaced bars 85 mounted in the upper portion of sump tank 7 to which water to be frozen is fed and to which unfrozen water falls from the freezing tubes. At the front of sump tank 7 there is a chute 87 through which ice cubes fall as they leave grill 83.

At the beginning of the harvesting operation the columns of ice are released by passing hot gas into the evaporator 9, and at the same time the ice cutter motor 37 is started so as to rotate shaft 69. This rotation acts through eccentrics 67 and rollers 65 to oscillate frame 57 and bar 51. As the columns of ice fall from the freezing tubes they are stopped in their downward movement by the ice-holding bar 75. However, each time that the cutter bar moves to the right, arm 71 engages arm 73 and this swings the ice-holding bar to the left out of the path of the columns of ice with the result that the columns of ice fall onto grill 83. Furthermore, movement of the cutter bar projects the points of the picks into the columns of ice and the ice is of such texture and temper that it breaks clean, thus cutting a length from the bottom of each column of ice and forming a cube. The cubes slide to the left along bars 85 into chute 87, while the continued rotation of shaft 69 moves the cutter bar and the picks further to the left. This moves the ice-holding bar to the right under the ends of the columns of ice and the columns of ice fall onto this bar and are held until the cutter bar starts to the right again in its next cutting movement. This operation continues with a length of the columns of ice being cut off during each rotation of shaft 69 until all of the columns are cut into cubes.

As indicated above, during the freezing operation water is pumped into header 3 at the top of the freezing tubes and it flows down the entire inner surfaces of each of the freezing tubes. The refrigeration system is operated to maintain the freezing tubes at a temperature low enough to produce a relatively rapid formation of ice on the inner surfaces of the freezing tubes. This ice builds up within the tubes in the form of columns having cylindrical openings therethrough. As the freezing continues these openings become smaller until the flow of water through the freezing zone, that is, beneath the nozzles, is interfered with; and, at that time, the freezing operation is stopped and the harvesting operation is started. In accordance with the present invention, the backing up or accumulating of water at the entry to the freezing zone is utilized to perform the function of stopping the freezing operation and starting the harvesting operation. Accordingly, connected into the top of each of the freezing tubes adjacent the nozzle is an inverted U-tube or siphon tube 89 mounted in header 3 and projecting to the left (Figures 2 and 5). The left-hand ends of these siphon tubes are connected to a common header pipe 91 which extends along the side of header 3. Thus, the annular space around the top of each nozzle within the freezing tube is connected through a siphon tube to header pipe 91. The nozzles direct fairly definite jets of water downwardly along the tube walls, and therefore, these annular spaces around the nozzles are normally occupied by air. However, when the flow of water down any one of the tubes is interfered with so that the water backs up or accumulates in the top of the tube, these spaces become filled with water and continued backing up causes water to flow up the connected siphon tube over to header pipe 91.

As shown in Figure 4, header pipe 91 extends to the right along the side of header 3 and thence downwardly to a bracket 93 where it projects into the open end of a slightly larger pipe 95. Pipe 95 has a reduced lower portion in which is centrally positioned the bulb 97 of thermostatic switch 47 which has a tube 98 extending upwardly in pipe 95 at the side of the lower end of header pipe 91 and thence to the switch assembly 47. Pipes 91 and 95 are normally filled with air which is at the ambient temperature of perhaps 60° F. to 80° F. so that bulb 97 is at this temperature. During operation, as referred to above, when the ice column in any freezing tube builds up sufficiently to restrict flow of water from the nozzle, the water backs up in the top of that particular freezing tube and then starts to flow upwardly through the connecting siphon tube to header pipe 91. From header pipe 91 the water flows to the right and thence downwardly (Figure 4) onto bulb 97. This water is at a temperature in the neighborhood of 32° and bulb 97 is therefore immediately cooled. As will be explained below this cooling of bulb 97 is utilized to stop the freezing cycle and to start the harvesting operation.

Positioned near the top of the central freezing tube is the bulb 99 of thermostatic switch 33 (Figure 1). Thermostatic switch 33 is so adjusted that it closes when the temperature of the freezing tubes is substantially above 30° and the switch opens again when the temperature drops below 32°, and thermostatic switch 47 is closed when the temperature of its bulb 97 is above 44° and this switch opens when the temperature of its bulb drops below this temperature. In Figure 1 the elements are shown at the start of the freezing cycle when the freezing tubes are still at ambient temperature. Thus, the closing of switch 23 starts the compressor motor 14 and switch 33 being closed solenoid 41 is energized so that its armature 29 is lifted. The raising of this armature opens the circuit of the ice cutter motor 37 and solenoid 21 and it energizes the water circulating pump motor 39 so that water is supplied to the freezing tubes. Furthermore the raising of armature 29 energizes switch 47 and this switch being closed an interlock circuit is set up for switch 31 thus connecting solenoid 41 through armature 29, contact 45, and switch 47 to line 25. Therefore, when the temperature of the freezing tubes drops so that switch 33 opens this interlock circuit holds solenoid 41 energized and continues the freezing operation as long as switch 47 is closed. During normal operations switch 47 remains closed until at least one of the columns of ice has its central opening reduced sufficiently to materially restrict the flow of water therethrough. At that time the water backs up as outlined above in the top of the freezing tube and flows through the siphon tube and the header pipe 91 and falls onto bulb 97. This immediately cools the bulbs and opens switch 47 so that solenoid 41 is deenergized and armature 29 drops. This disconnects line 25 from pump motor 39 so that water is no longer supplied to the freezing tubes. Armature 29 falls into engagement with contact 43 so that line 25 is connected to solenoid valve 21 and the ice cutter motor 37, the other side of each of which is connected to line 27. Therefore, solenoid valve 21 is opened and the cutter motor is started, thus initiating the harvesting operation. The operation of the compressor continues so that the opening of valve 21 causes the hot refrigerant gas to flow from the compressor directly to the evaporator. This heats the freezing tubes so that the columns of ice are released and the ice cutter motor 37 is operated to cut the ice into cubes as outlined above. The harvesting operation continues until the temperature of the freezing tubes rises to a valve which indicates that they are free of ice and the cycle of operations is then repeated.

With this arrangement the ice freezes through substantially the same thickness at all times even though there are variations in the ambient and water temperatures. Furthermore, if for any reason there is a stoppage in one of the tubes due to a failure of the ice to clear during the previous harvesting operation the freezing operation will be terminated and a harvesting operation will be started immediately. Thus, the arrangement is such that the normal control acts as a safety protective device. The operation of the machine is efficient and dependable at all times.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In apparatus of the character described, the combination of, ice forming means including a plurality of passageways through which liquid to be frozen flows and within which ice forms whereby the flow is restricted, means to supply the liquid to be frozen to said passageways, means forming an outlet at the entrance of said passageways whereby liquid flows through said outlet when there is a restriction in the flow through said passageways, and control means responsive to the flow of liquid through said outlet to discontinue the freezing operation.

2. In ice making apparatus, the combination of, a bank of freezing tubes, means to flow water through said tubes, means to refrigerate said tubes whereby ice builds up, discharge means connected to the entrance of one of said tubes so constructed and arranged that water will flow therethrough when there is a restriction in that tube, and means responsive to the cooling effect of liquid flowing through said discharge means to effect the termination of the freezing operation.

3. In ice making apparatus, the combination of, a bank of freezing tubes, liquid circulating means to circulate liquid to be frozen through said tubes whereby ice builds up within the tubes, liquid discharge means connected to the tubes at the point where the liquid flows therein whereby the liquid flows through said discharge means when there is a restriction to the flow of liquid through the tubes, and control means responsive to the flow of liquid through said discharge means.

4. In ice making apparatus, the combination of, a bank of vertical freezing tubes, a header having nozzles projecting into the tops of said tubes, a plurality of siphon tubes connected respectively to the tops of the freezing tubes adjacent said nozzles, and a thermostatic switch having a bulb so positioned that liquid which flows through said siphon tubes will cool the bulb.

5. In ice making apparatus of the character described, the combintion of, a bank of vertical freezing tubes, a header having nozzles which direct streams of water into the tops of said tubes, a siphon tube connected to the top of one of said freezing tubes adjacent its nozzle and so constructed and arranged that liquid will be discharged through the siphon tube when there is a restriction in the flow through that freezing tube, and a thermostatic switch having its bulb so positioned that any liquid flowing through said siphon tube will flow thereon.

6. Apparatus as described in claim 5 wherein there is a plurality of siphon tubes connected respectively to each of said freezing tubes, a header pipe connected to each of said siphon tubes and having a downwardly projecting discharge end, means to receive liquid from said discharge end, and means mounting said bulb so that liquid from said discharge end flows thereon.

7. In ice making apparatus, the combination of, a bank of freezing tubes, a refrigerant evaporator positioned to cool said tubes, means for circulating liquid through said tubes whereby ice builds up within the tubes, discharge means connected to the tubes whereby the liquid flows through said discharge means when there is a restriction to the flow of liquid through said tubes, and means responsive to the flow of liquid through said discharge means for discontinuing the freezing operation and initiating a harvesting operation.

8. In ice making apparatus, the combination of, a bank of freezing tubes, a refrigerant evaporator positioned to cool said tubes, means for circulating liquid through said tubes whereby ice builds up within the tubes, means responsive to the restriction to the flow of liquid through said freezing tubes for stopping the freezing operation, and means for starting another freezing operation when the temperature in said freezing tubes rises above a predetermined value.

9. In the art of making ice, the steps of, refrigerating the limiting surfaces of a passageway which is adapted to be restricted by the forming of ice on said surfaces, feeding water along a path to the entrance of said passageway and thence along said limiting surfaces through said passageway until sufficient ice has been formed to restrict the flow of water and cause the water to accumulate at the entrance to said passageway, conducting the water from the entrance of the passageway to a control zone, and utilizing the presence of the water at said control zone to terminate the refrigerating of said passageway and to initiate a harvesting operation to free the ice from said limiting surfaces.

10. In the art of making ice, the steps of, flowing water to be frozen along a closed passageway which includes a freezing passageway through which the water flows by the action of gravity and a supply passageway through which the water flows to the top of said freezing passageway, refrigerating said freezing passageway whereby ice forms to restrict the flow of water therethrough with the result that water backs up above where the flow is restricted, and utilizing said back up of water at the entrance to the freezing passageway to terminate the freezing operation.

11. In the art of making ice, the steps of, refrigerating a conduit to a temperature below that at which water freezes, feeding water into one end of said conduit and permitting the water to flow therethrough whereby ice builds up in sufficient quantity to restrict the flow of water through the conduit, continuing the feeding of water to the conduit thus restricted so as to cause the water to overflow from the inlet end of the conduit, conducting the overflowing water to a control zone, and utilizing the water at said control zone to initiate an ice harvesting operation to freeze the ice from the conduit.

12. In ice-making apparatus of the character described, the combination of, an ice-making assembly including a plurality of ice-making conduits through which water to be frozen flows and within which ice forms on the conduit walls so as to restrict the flow, a water supply assembly to supply water to said ice-making conduits, water outlet means forming an outlet at the entrances to said ice-forming conduits whereby water flows through said water outlet means when there is a restriction in the flow through said ice-forming conduits, and control means responsive to the flow of water through said water outlet means to discontinue the ice-making operation.

13. In ice-making apparatus, the combination of, a bank of freezing tubes, water feed means to flow water through said tubes, refrigerating means to refrigerate said tubes whereby ice is formed on the walls thereof, water discharge means connected to the entrance of one of said tubes so constructed and arranged that water will flow therethrough when there is a restriction in that tube, a thermostat bulb positioned in a water outlet passageway which comprises a portion of said water discharge means, and control means including a switch adapted to be opened and closed in accordance with the temperature of said thermostat bulb, said control means being effective to terminate the freezing operation upon the operation of said switch.

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