With apparatus such as that referred to above, difficulty has been encountered in producing uniform high quality ice without the attention of an operator. Machines such as those referred to above have, however, been sold as "package units"; that is, self-contained units are built and sold for installation by the purchaser, and the operation by making connections to the water supply and drain and to a source of electric power. The operation is then automatic with the ice-making and harvesting operations being carried on in accordance with a controlled cycle. Under some circumstances the salt concentration is high so that there is a tendency for the ice to become cloudy and commercially unacceptable, and special care must be taken to maintain the salt concentrations within permissible limits. It is advisable, however, to avoid complicated and costly equipment and to use a minimum amount of water consistent with the production of maximum quantities of commercially acceptable ice.

An important feature of this type of equipment from a commercial standpoint is that the ice produced is uniform in size and shape and, of course, of high quality; that is, the ice cubes are clear and hard and of substantially the same size and shape. It has been found, however, that apparatus such as that referred to above will, under some conditions of operation, produce ice which is not uniform and, in fact, which is not entirely satisfactory from a commercial standpoint. For example, if the ice builds up at an excessive rate in one particular tube it may freeze solid and become sub-cooled excessively prior to the end of the freezing cycle and then part or all of it may not become dislodged during the harvesting cycle. If due to this or another cause, a body of ice remains in one of the freezing tubes after a harvesting cycle has been completed, there is no container to hold the tube will be damaged during the next freezing operation.

Provision has been made in apparatus of the above character for preventing the completion of a freezing operation if one or more of the tubes are obstructed. However, it is still important to insure that ice builds up at the desired rate in all of the freezing tubes. As indicated above, with this type of apparatus, when water is flowed down the inner walls of the freezing tubes at a very rapid rate, clear and hard ice forms in an even layer. This is because the rapidly flowing layer of water against the top of each of the four side wall surfaces of each tube. Thus, the four streams are projected into each tube from corresponding outlets or openings in a nipple or water distributor in the bottom of a water header or from the pressure of the water circulating pump referred to above. As discussed in the preceding application of Rodney F. Lauer and Claude V. Shurtuff, it was found that one or more of the outlets from these nipples was apt to become clogged; for example, by the accumulation of crystallized salts when the salt concentration is high. When one or more of the water outlets in a nozzle became clogged there was a corresponding decrease in the rate at which water flowed through that tube. Thus, while the water tended to spread out over the entire inner surface of that tube, the rate of water flowing through that tube was largely decreased, with the result that the smaller quantity of water which was delivered to the tube. This reduced rate of water flow not only caused the ice in that tube to become milky or even white and spongy, but this reduced rate of flow caused the ice to build up at an increased rate so that that particular tube became filled with a column of ice prior to the completion of the freezing operation in the other tubes. For example, at the times the ice completely filled one tube while relatively thin shells were formed in the other tubes.

In the apparatus of Serial No. 57,158 the harvesting operation is initiated whenever one or more of the tubes becomes filled with ice sufficiently to interfere materially with the flow of water therethrough. This is extremely satisfactory as a mode of control for most conditions of operation because the freezing is uniform in the various tubes and they all become substantially filled with columns of ice of high quality at substantially
same time; that is, by the time one or more of the tubes has the water flow obstructed by the ice sufficiently to initiate the harvesting operation. However, with such conditions it has been found that, under some circumstances, the ice obstructing the water supply openings is filled with water, and while the other tubes have only shells of ice in them, and therefore, the apparatus produces no ice of acceptable quality and size.

With the invention of the above-identified application of Rodney F. Laufer and Claude V. Shurtluff, arrangement is provided for insuring that the water will be distributed evenly and will flow continuously down all of the tube surfaces throughout the entire freezing cycle. That invention contemplates a water distribution arrangement wherein solid particles such as crystallized salts or foreign matter will not interfere with the flow. Thus, the freezing cycle will be carried on to completion without danger of being stopped by the permanent buildup of ice in the tube. Furthermore, the water is delivered to the tubes in such a manner that it does not tend to flow at a reduced rate through any area of the freezing surfaces of the tubes.

As indicated above, the present invention is in a sense an embodiment of an apparatus on which that described in the above-identified application of Rodney F. Laufer and Claude V. Shurtluff, is provided.

The present invention provides an improved construction for carrying out the above. Water flows into the tops of the freezing tubes through unobstructed pipes and it hits a target which is dish-shaped so that the water is directed radially outwardly and upwardly. The target is supported in such a way that it is rigid and yet it may be removed readily for servicing. One illustrative embodiment of the invention is particularly adapted for installation on up-to-date makes as such an embodiment is disclosed in the above-identified copending application of William M. Grandala while the other illustrative embodiment is related more closely to the apparatus disclosed in the above-identified application of Rodney F. Laufer and Claude V. Shurtluff.

In the drawings:

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

Figure 2 is an enlarged top plan view with parts broken away of the water distributor outlet of Figure 1;

Figure 3 is a side elevation with parts broken away of the header of Figure 2;

Figure 4 is an end elevation of the header of Figures 2 and 3;

Figure 4A is an enlarged plan view of the water distributor outlets with the center broken away and showing the enlarged size of the outlets to the end tubes;

Figure 5 is an enlarged sectional view of the water distributing nozzle of Figure 3;

Figures 6 and 7 are similar to Figures 2 and 3 respectively, but show another embodiment of the invention.

Figures 8, 9 and 10 are sectional views respectively on the lines 8—8, 9—9 and 10—10 of Figure 7; and,

Figure 11 is a section on the line 11—11 of Figure 10.

Referring to Figure 1 of the drawing there is illustrated schematically at the top a bank of sixteen freezing tubes 1 to the tops of which water is directed by a header 3, supported by a supporting member 4 from a sump tank 7. The water flows down the tubes and some of the water, 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 and cooled by the water is provided for maintaining a predetermined level in the tank. The freezing tubes are cooled by an evaporator 9 to which liquid refrigerant is supplied through a thermostatic valve 11 having a bulb 12 located inside the evaporator, the bulb being 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 16 cooled by water supplied through valve 18. The refrigerant is here liquefied and passed to the evaporator. 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) is provided 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 tank when necessary. Power to operate the machine is supplied through a main control switch 23 to a pair of lines 25 and 27 which are connected electrically to power the compressor and the electric motor. Switch 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 is connected to one side of each of the solenoid valves 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 the circuit to which contact 43 is connected. That circuit also includes a normally-closed contact 43 connected to the other side of the solenoid of valve 21 and to that of 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 water distributor and the associated parts have been explained in detail.

Referring to the upper portion of Figure 1, there is shown the bank of square freezing tubes 1 positioned in side-by-side relationship with a plate 48 between the sides walls of each of two adjacent tubes. On the opposite sides of the bank of tubes there are two evaporator sections which are surrounded by thin 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. At the top of the bank of tubes there is a horizontal water supply header 53 which is enclosed in an insulation shell and projecting from the bottom wall of this header into the top of each of such tubes is a water distributor nozzle 54 (see Figure 3) which directs water against the inner surfaces of the four walls of its tube.

At the bottom of the freezing tubes there is an ice cutting assembly not shown but described in detail in the above-identified applications. This assembly severs the columns of ice which are formed in the tubes into lengths to form the ice cubes which are passed by gravity to a storage bin. At the beginning of the harvesting operation the columns of ice are released by passing hot gas into evaporator 9 and at the same time the ice cutter assembly is started. This operation continues until the temperature of the evaporator rises, thus indicating that the ice has been freed and has dropped from the freezing tubes. At this time the harvesting operation is stopped and the water storage tank is emptied by closing the water discharge valve 52 which is connected to the bottom end of the water supply header 53 and downwardly through the bottom wall of this header. Thus, each tube 52 connects the upper end of one of the freezing tubes to the top of header 49, and it projects downwardly through the water supply header 53 and the top wall of header 49.

As indicated above, header 53 has water distributor nozzles 54 mounted in its bottom wall; illustratively, there are sixteen freezing tubes opening through each tube and its nozzle being in axial alignment. As best shown in Figure 5, each of the nozzles comprises a sleeve or ferrule 55 and a target or deflector 56. Ferrule 55 is supported by the bottom wall of header 53 and central water outlet opening 57 through which water is discharged from the header. Target 56 is somewhat dish-shaped and it is supported by two integral arms 59 which
2,701,452 5 (see Figure 3) extend outwardly and upwardly and have their ends bent inwardly so that they engage an annular groove S8 at the lower end of ferrule S5. During operation the water from header 53 flows through each of the nozzles in a rapidly moving stream and the stream is projected against the inner surface of target 56. Target 56 spreads the water and causes it to flow radially in a smooth thin stream or sheet outwardly against the tube walls. The upturned rim of the target causes the water to be forced outwardly so that the water engages the tube walls at substantially the top of the tube. Thus, as described above, the water flows downwardly along the tube walls and it tends to spread evenly and to flow at a rapid rate. It should be noted that the nozzles provide unobstructed water discharge outlets from the header into the tubes. Thus, particles of even a relatively large size are caught by the revolving motor and are washed down into the tubes into the sump tank without in any way obstructing the flow of water.

The water discharge header 49 is connected (Figure 1) to the downwardly extending pipe 91 and water is supplied from pump 5 to header 53 through a pipe 90. The left-hand end of header 49 is vented at the left through an inverted U-tube 92. Pipe 91 projects downwardly into the arms 112 and the upper end of a portion 95 which extends to the sump tank 7. Thermostatic bulb 97 of switch 47 is positioned in pipe 95 so that water flows over it from pipe 91 and the bulb is connected through a tube 98 to switch 47.

The freezing operation has been described above and for more detailed discussions of it reference may be had to the above-identified copending application. For purposes of understanding the present invention, it is sufficient to point out that with the system operating as represented in Figure 1 water flows through the nozzles 54 and thence downwardly through the freezing tubes while the freezing tubes are cooled by the refrigerating system discussed above. Ice of high quality builds up on the tube walls in the forms of columns or tubes which are successively bent so as to prevent cold air from passing through them. As the freezing continues, these openings become smaller until the flow of water through the freezing zone is interfered with, at the time the water tends to back up into the top of the tubes. The water which backs up in any tube tends to flow upwardly through the connecting overflow tube 52 and over into the header 49 (see Figure 5) and in header 49 flows to the right (Figure 1) and thence downwardly through pipe 91 and over bulb 97. This water is cooled and it reduces the temperature of bulb 97 sufficiently to open switch 47 and to stop the freezing operation.

It should be noted that switch 33 has its bulb 99 positioned near the top of the bank of freezing tubes and this switch closes and the bulb temperature rises substantially again when the temperature drops. Thus, during the freezing operation this switch is open and, therefore, the opening of switch 47 deenergizes solenoid 41 so as to drop armature 29 away from contact 45, thus stopping the pumping motor 39. Armature 29 drops into engagement with contact 43 and this energizes the solenoid of valve 21 so as to open this valve and supply hot gas to the evaporator and it also starts the cutting motor 37. The pumping motions are therefore thawed from the freezing tubes and they drop down and are severed into cubes by the mechanism operated by motor 37.

When the tubes are free of ice their temperature rises rapidly so that bulb 99 is heated and its switch 33 closes. This energizes solenoid 41 so as to raise armature 29 with the result that the motor is stopped and the solenoid of valve 21 is deenergized so that this valve recloses and hot gas is no longer supplied to the evaporator. The raising of armature 29 restarts the pumping motor and cold water has ceased to flow from the tops of the tubes through pipe 91 with the result that the temperature of bulb 97 has risen and switch 47 has reclosed. Thus, switch 47 provides the interlock circuit which holds solenoid 41 energized after the next freezing operation has restarted and the cycle is therefore repeated.

Referring to Figures 6 to 11 of the drawings which show another embodiment of the invention, a pair of sheet metal shells 60 and 61 form respectively, a water inlet passageway 86 and a water discharge passageway 88. These shells are fabricated of sheet metal with soldered or welded seams and they have removably attached left-hand end wall 68 which is clamped in place by four thumb screws 76 attached to four end brackets 78 which are welded to the side walls of the shells. A gasket 80 on the inner surface of the shells prevents leakage at the openings. The shells are clamped in place by bolts (not shown) extending through a plurality of tubular brackets 82 welded to the side walls of the shells. The entire header is enclosed in foam rubber insulation 80 and the shells are spaced apart by strips of foam rubber 72.

The header 3 is provided with sixteen nozzles 100 which are positioned respectively, at the tops of the various freezing tubes 54. Each of the nozzles is provided with a water discharge pipe or tube 102 which is welded to the bottom of shell 60 and projects downwardly and is unsupported into the top of the freezing tube. Centrally positioned around tube 102 is an overflow sleeve or tube 104 which is soldered in the bottom wall of shell 61 and has its upper end projecting above the center of the water discharge passageway 88 in this shell. The lower end of tube 104 projects into the top of the freezing tube and has an annular external groove 106 therefrom which is supported a target member 110 having a bore of bale-like target portion 114.

Target member 110 is identical with the similar member 56—59 of the embodiment of Figures 1 to 5 and (see Figure 11) the upper ends of arms 112 are bent toward each other and are enlarged to form washers which are welded to the top surfaces 116. These end surfaces are resiliently held against the bottom of the groove 106 and (see Figure 7) the sponge rubber member which forms part of insulation 70 presses resiliently against the stationary target member in the manner discussed above in connection with the embodiment of Figures 1 to 5.

An overflow dispensing arrangement is also provided by the annular space between the two tubes 102 and 104 through which water is discharged into passageway 88, but tube 104 extends upwardly into passageway 88 so that water does not flow in the reverse from this passageway into any of the freezing tubes. Passageway 88 is provided at its right-hand end with a vent pipe 108 which prevents abnormal pressure or vacuum conditions to build up in the passageway. The water supply pipe 90 is connected to the right-hand end of the water pump connected to the right-hand end of shell 60 thus to supply water to passageway 86 and the water outlet or discharge pipe 91 is connected to shell 61 thus to receive the overflow water from passageway 88.

The operation of this embodiment is similar to that discussed above, it being understood that water under pressure in passageway 33 for freezing 87, 93 of the respective tubes, etc. At the end of the freezing operation cold water from one or more of the tubes flows upwardly through the respective pipes 104 and thence through passageway 88 into pipe 91 to initiate the harvesting operation. The concentric arrangement of the water supply and discharge passageways of the nozzles has advantages particularly under some conditions of operation and with certain types of machines.

As pointed out above, in both of the illustrative embodiments of the present invention the overflow discharge passageway is vented to atmosphere; that is, in Figures 1 to 4 a vent 92 is provided and in Figures 6 to 9 a vent 108 is provided. As stated, these vents maintain atmospheric pressure in the overflow discharge passageway which, as indicated, are opened and closed by valves 112.

It has been found that this arrangement has particular advantages with ice-making machines such as those of the illustrative embodiments. With such a machine the normal freezing behavior is such that the water flows down the tube walls in an open free flow during the beginning of each freezing cycle. That is to say, the tube is not full of flowing water, but there is a rapidly moving sheet of water covering the tube walls, and there is a column of air down the center of the tube. As freezing progresses and the holes in the tubes become smaller, a point is reached in one or more tubes when there is a sudden bridging over so that the air of air disappears and there is no longer a free flowing layer of water; but rather, there is a solid column of water which occupies the entire opening at the center of the
column of ice. This sudden bridging over effect tends to cause a partial vacuum condition to exist because the solid column of water tends to carry air with it so that the tube, in effect, acts as an aspirator. The partial vacuum condition is transmitted to the overflow discharge passageway and through it to the tops of the other tubes, most of which may still have a column of air in them with the free flow of water down their walls. This causes air to flow back up the tubes which still have columns of air in them at that instant and the upward passage of air tends to interrupt the downward flow of water and water is carried with the air into the overflow discharge passageway. At times this flow has been sufficient to initiate the harvesting cycle which, as will be understood, is premature because none of the columns is frozen solidly and most of them have a substantial opening through them.

With the vent arrangement herein disclosed, the partial vacuum condition is relieved by the vent and, therefore, the partial vacuum condition in one tube is not transmitted to another. Thus, the mode of operation discussed above is carried on without danger of the freezing operation being stopped prematurely.

Under some circumstances, it is desirable to vary the sizes of the nozzles or otherwise to control the water flow through them. In this way it is possible to insure uniform building up of ice where the freezing tubes are cooled at different rates. Thus, in the embodiment of Figures 1 to 5 there is a tendency for the tubes at the two ends of the bed to cool more rapidly than the middle and this means that effects of the bends at the ends of the runs of the evaporator sections. This non-uniformity of cooling of the tubes is compensated for by flowing water at a more rapid rate through the two end tubes than through the other tubes. Thus, the greater quantity of water flowing through these tubes carries away heat more rapidly, and ice builds up at a slower rate. It is therefore contemplated that the flow be so adjusted in each tube as to give the desired rate of building up of ice; illustratively, the flow through each tube is somewhat proportional to the rate of build-up.

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 ice-making apparatus of the character described a water distributor system which includes, a closed water supply header having outlets spaced along its bottom wall and adapted to project solid streams of water respectively into the tops of the various tubes of a bank, target means positioned in the tops of the respective tubes in the line of the water flow and adapted to divert the water outwardly and upwardly within each tube against the tube walls thereof, and venting means connected to the tops of said tubes and extending therefrom to substantially atmospheric pressure.

2. Apparatus as described in claim 1 which includes, an overflow discharge header connected to receive overflow water individually from the tops of the tubes and providing said vent means therefor.

3. Apparatus as described in claim 1 wherein the size of the outlet is varied to control the flow to each tube with respect to the freezing rate so that ice builds up substantially evenly in the various tubes.

4. In ice-making apparatus of the character described, the combination of, a plurality of freezing tubes which are provided with inner freezing surfaces which are refrigerated so that ice will form thereon to form ice bodies, and water distributor means to supply water to said tubes including a header and a plurality of nozzles connected to said header and associated respectively with said freezing tubes with each nozzle projecting into the upper end of its tube and having an unobstructed outlet which is circular in cross section and has its axis substantially concentric with the axis of its freezing tube, each of said nozzles including a deflector positioned in the top of the tube and formed by a plurality of supporting arms and a target portion which is substantially less in diameter than the smallest transverse dimension of the tube whereby there is a substantial free opening, and the water flow from said water distributor in the various tubes being controlled in substantially a direct relationship to the rate of cooling of each tube whereby ice builds up substantially the same rate in each tube.

5. In ice-making apparatus of the character described, the combination of, a plurality of vertical freezing tubes which are provided with inner freezing surfaces which are refrigerated so that ice will form thereon to form ice bodies, a water distributor means connected to a reservoir of water, a water distributor means connected to said discharge means whereby abnormal pressure conditions in one tube do not substantially alter the operations in the other tubes, and water distributor means to supply water to said tubes including a header and a plurality of nozzles connected to said header and associated respectively with said freezing tubes with each nozzle projecting into the upper end of its tube and having an unobstructed outlet which is circular in cross-section and has its axis substantially concentric with the axis of its freezing tube, each of said nozzles including a deflector positioned in the top of the tube and formed by a plurality of supporting arms and a target portion which is substantially less in diameter than the smallest transverse dimension of the tube whereby there is a substantial free opening.

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