The present invention relates to an automatic ice maker and is more particularly concerned with a hydraulic ice maker for operation in the freezer compartment of a household refrigerator.

Automatic ice makers for household refrigerators normally comprise means for sequentially and automatically filling one or more mold cavities with water, freezing the water to form ice pieces and discharging the formed pieces into a suitable container. An ice maker of this type comprising a hydraulically operated piston for removing ice pieces from the mold and automatically supplying a new charge of water to the mold is described and claimed in co-pending patent application Ser. No. 512,723, filed December 9, 1965, in the names of Dwight W. Jacobus and William C. Bodong, and assigned to the same assignee as the present invention. It comprises a structure including a mold having at least one ice cavity and an ice ejecting means comprising a cylinder and piston assembly. The cylinder is connected to a source of water under pressure. The cylinder and piston are cooled to below freezing temperatures during formation of ice in the mold whereby during this freezing step, ice formed from residual water present in the cylinder freezes the piston in a lower or normal position against movement within the cylinder. After formation of ice in the mold cavity, thawing of the ice bond between the piston and cylinder walls by energization of suitable cylinder heating means permits upward movement of the piston under the pressure of a measured volume of water introduced into the lower part of the cylinder to an upper position in which ice is ejected from the mold. Means including a water passage extending through the piston and having its inlet end in the lower face of the piston are provided for transferring the volume of water from the cylinder to the mold cavity following removal of ice from the mold. This flow reduces the water pressure beneath the piston so that the piston can be returned to its lower position. For proper operation of the ice maker this piston passage must be closed or plugged by a body of ice which is formed therein during the freezing of the ice in the mold and which is melted only after the ejection step so that removal of ice from the mold cavity is assured prior to the introduction of a new charge of water into the cavity.

Under some operating conditions of the above-described ice maker, it has been found that the time delay period provided by the melting of the ice plug varied from cycle to cycle and occasionally resulted in flooding of the mold prior to the ejection of the ice therefrom. This erratic operation was found to result from the fact that during some cycles of operation air dissolved in the water remaining in the cylinder following the ejection step was released as a result of the decrease in water pressure. This released air filled or partially filled the passage therefor by preventing the subsequent formation of the ice plug or decreasing the size thereof.

It is an object of the present invention to provide a hydraulic ice maker of the above-described type including means for preventing air released from the water from interfering with the intended operation of the ice maker.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In accordance with the present invention, there is provided an improved hydraulic ice maker of the type described in the aforesaid Jacobus et al. patent application including means at the inlet end of the piston water passage for preventing air released from the water remaining in the cylinder following an ejection cycle from entering the passage but permitting the flow of both released air and water through the passage during the mold filling step. In the illustrated embodiment of the invention, this means comprises a relatively fine mesh screen having the desired action.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

FIGURE 1 is an elevational view, partly in section, of the ice maker structure of the present invention;

FIGURE 2 is an enlarged vertical sectional view taken along lines 2--2 of FIGURE 1 illustrating certain components of the ice maker during the ejection stage of operation;

FIGURE 3 is a sectional view along line 3--3 of FIGURE 2 illustrating the detailed construction of the air retaining means; and

FIGURE 4 is a schematic illustration of the overall ice maker and the control circuitry therefor.

Referring particularly to FIGURES 1 and 2 of the drawing, the automatic ice maker of the present invention includes a metal mold block 1 mounted on a frame 2 which in turn is adapted to be secured to the wall of a freezer compartment by means of a plurality of brackets 4. The mold block includes a plurality of ice cavities 7. These ice cavities 7 are shown as being arranged in groups of three on opposite sides of a cylinder 8 including an upper portion 9 which is at substantially the same elevation as the cavities 7 and a lower portion 10 extending below the plane of the cavities 7. The cavities 7 are separated from one another or from the upper portion of cylinder 8 by walls 11. Each of these walls includes a vertical passage 14 and provides means for the flow of water from the cylinder 8 into the various ice cavities 7.

The cylinder 8 and a piston 16 obtained within the cylinder provide hydraulic power means for ejecting the ice pieces from the cavities 7. During formation of ice pieces in the mold cavities, the piston 16, as is shown in FIGURE 1 of the drawing, is in its normal position with the bottom end 18 thereof adjacent to but spaced from the bottom wall 19 of the cylinder. An extended or upper portion 20 of the piston is normally disposed in the upper portion 9 of the cylinder 8. Secured thereto, or forming an integral part thereof, are ejecting pad structures 22. Each of these pad structures 22 comprises a tapered vertical member 23 normally contained in the slots or passages 14 in the walls dividing the upper portion of the cylinder from the adjacent cavities 7 and a horizontal arm 24 extending through the cavities 7 or more specifically through the remaining passages 14 and having therein pads 25 respectively positioned at the bottom of each of the cavities 7 during formation of the ice pieces.

The piston 16 is biased to its lower position within the cylinder 8 by means of a yoke 27 of inverted U-shape extending across the top surface of the upper portion 20 of the piston and biased downwardly by tension springs 28 connecting the yoke 27 to the piston anchors and shown) on the lower part of the ice maker structure.

The ice maker also includes a mold cavity heater 31 positioned adjacent the lower perimeters of the cavities 7 and a cylinder heater 32 in heating relationship with the lower portion 10 of the cylinder 8. A mold thermostat 34 and a safety thermostat 35 are provided for pre-
venting operation of the ice maker under abnormal mold temperature conditions.

A measured volume of water for operating the piston 16 to eject ice pieces from the mold and for filling the cavities 7 is supplied to the mold structure 1 through supply line 40 connecting the bottom wall 19 of the cylinder 8 with a measuring vessel 41 as shown in FIGURE 4 of the drawing. The measuring vessel, positioned on the floor for convenience in an above freezing ambient, includes a water chamber 42 formed in part by a flexible rubber diaphragm cup 43. Water is supplied to the measuring vessel through a conduit 44 connected to a high pressure water source, such as a city water supply, under control of a normally closed solenoid valve 45. A plunger 46 bearing against the bottom of the diaphragm 43 and a compression spring 47 engaging the plunger 46 furnish the pressure required to operate the piston 16 when the valve 45 is closed.

Means for conveying the measured volume of water from the cylinder 8 to the cavities 7 following an ejection cycle comprises a T-shaped passage 50 within the piston 16. This passage includes a vertical inlet portion 51 and a pair of outlets 52 in the vertical side walls of the piston 16.

The present invention is directed to an improved construction of this passage and particularly the inlet portion 51. However, as the advantages of and reasons for the improved construction will become more apparent following a consideration of the over-all operation of the ice maker, the detailed description thereof will be set forth hereinafter.

Additional components, control means and circuitry for automatically controlling the operation of the ice maker through its various cycles includes a toggle switch 54 and a switch operating arm 55 connected to the plunger 46 for operating the toggle switch 54 (FIGURE 4) and a bin switch 56 for interrupting the operation of the ice maker when a storage bin or receptacle 57 into which the ice pieces are discharged from the mold becomes filled.

In describing the operation of the ice maker, it will be assumed that the bin switch 56 is closed, that the mold is at a temperature such that the safety switch 53 is also closed, that the toggle switch arm 59 forming part of the toggle switch 54 is in engagement with the contact 60, the chamber 42 empty and the piston 16 is in its lower position. The mold heater thermostat switch 34 is open and a supply line heater 63 connected directly across the electric power lines 64 is energized to maintain the supply line 46 adjacent the cylinder 8 or in other words that portion of the supply line within the freezer compartment at above freezing temperatures.

As the temperature of the mold decreases to the point indicating that a charge of water previously supplied to the mold cavities 7 has frozen, the mold heater thermostat 34 will close thereby energizing the solenoid valve 45 through a circuit which includes the mold heater thermostat 34, the contact 60 of the toggle switch 54 and the bin switch 56. Opening of the solenoid valve 45 allows water under pressure from the household water supply line 44 to enter the chamber 42 and displace the plunger 46 against the biasing action of the spring 47. When a predetermined volume of water has been introduced into the measuring vessel 41, a stop 66 on the arm 55 trips the switch arm 59 to open the circuit including the solenoid valve 45 and to complete a circuit through the switch contact 66 for energizing the mold heater 31 and the cylinder heater 32.

During filling of the chamber 42, the piston 16 does not move due to the fact that it is frozen to the inner surface of the cylinder 8 by a film of ice within the clearance 70 between the walls of the piston 16 and the cylinder 8. Water flowing through passage 50 to the cavities 7 by this film of ice as well as a plug of ice formed within passage 50.

Energy of the heaters 31 and 32 warms the walls of the cavities 7 and the cylinder 8 to release the ice pieces contained within the cavities 7 and melt the ice bond between the piston and cylinder walls. Preferably the mold heater 31 and the cylinder heater 32 are sized so that the ice pieces are thawed free of the cavity walls before the ice bond between the walls of the piston 16 and the cylinder 8 is broken.

The thawing of the ice bond between the piston and cylinder walls frees the piston for movement under the pressure of the water in the measuring vessel 41. The piston and the ejection structure 22 move upwardly to lift the ice pieces out of the cavities 7. As the piston 16 approaches its upper position, the ice pieces are engaged by a sweep 76 pivotally supported on the frame. The sweep 76 is preferably inclined relative to the direction of travel of the ice pieces whereby the initial contact of the ice pieces with the sweep 76 breaks the ice pieces free of the pads 25 and adjacent portions of the ejection structure 22.

As the piston 16 continues to move towards its upper position in contact with a stop 78, the yoke 27 engages a finger 80 forming part of the sweep 76 whereby the sweep is caused to rotate about its pivotal axis 81 and sweep the ice pieces from the top of the mold into the storage bin 57 positioned below the mold.

During this upward travel of the piston 16, water is prevented from flowing through the bypass passage 50 by the ice plug formed therein during the ice freezing cycle. Melting of this plug after the piston reaches the top of its stroke permits the flow of water through the passage 50 to relive the hydraulic pressure within the cylinder 8 so that the springs 28 return the piston to its lower position adjacent the bottom wall 19 of the cylinder. During this return movement of the piston, most of the remaining water from the measuring vessel flows through the bypass passage 50, upwardly through the clearance space 70 between the piston and cylinder and through the passages 14 into the mold cavities.

The mold thermostat 34 opens in response to a predetermined elevated temperature of the mold so as to prevent energization of the solenoid valve 45 when the plug valve plunger 46 is returned to its normal position by the spring 47. During return movement of plunger 46, a second stop 83 on the arm 55 throws the toggle switch arm 59 out of engagement with contact 65 to de-energize the mold heaters and into engagement with contact 60 whereby the control circuitry for the solenoid valve 45 is reconditioned for operation of the valve following transport closing of the mold heater thermostat 34. Operation of the ice maker through repeated filling, freezing and harvesting cycles is normally continued until such time as the bin switch 56 is opened as a result of the collection of the desired quantity of ice in the storage bin.

From the above description, it will be seen that the operation of the subject ice maker is controlled in part by the formation and thawing of the ice plug within the water passage 50. The presence of the ice plug assures maximum water pressure for lifting the piston 16 after the ice bond between the piston and the cylinder wall has been thawed. It also provides for the delay in the flow of water from the cylinder to the mold cavities until after the previously formed ice has been ejected. These functions were accomplished in accordance with the teachings of the aforementioned Jacobs et al. patent application by lining the walls or at least a portion of the passage 50 with a suitable heat insulating material designed to delay the melting of the ice plug for the proper period of time. Even though this heat insulating insert was designed to give a controlled delay time, it was found that, in actual operation of the ice maker, the delay times were not consistent and that under some conditions water flowed through the passage 50 immediately upon the thawing of the bond between the piston and cylinder walls, that is, prior to or during the ejection of the ice from the mold. This problem was found to re-
sult from the fact that air dissolved in the high pressure water introduced into the cylinder 8 and released under the low pressure conditions prevailing after return of the piston to its normal position collected in and filled or partially filled the passage 50. The presence of this air caused the delay times to vary by changing the amounts of water present in the passage for the formation of the ice plugs.

In accordance with the present invention, means are provided for assuring consistent operation of the ice maker by preventing air released from the low pressure water remaining in the cylinder 8 from migrating into the passage 50 and interfering with the formation of the required ice plug therein. More specifically, as shown in FIGURES 2 and 3 of the drawing, the lower end of the metal piston 16 is so constructed as to provide not only the desired thermal delay but also to prevent released air from entering the passage 50. To this end the piston is provided with an internally threaded cavity 85 for receiving the threaded shank portion 86 of a plastic liner or insert member 87 having a head portion 88 adapted to secure a rubber washer 89 and a flexible plastic plunger seal 90 to the bottom end of the piston 16. The plastic member 87 includes an axially extending passage 91 for threadably receiving a screw 92 having one or more longitudinally extending slots 93 which in combination with the interior of the passage 91 form the water passages comprising the lower or inlet end portion 51 of the passage 50. The lower or inlet end of the portions of passage 51 formed by the slots 93 is covered with a fine metal mesh screen 94 positioned within the flared lower end of the plastic insert 87 and held therein by means of the head of the screw 92. Spaced ribs 98 space the screen 94 from the adjacent surfaces of the member 87.

The screen 94 is designed to allow both high pressure water and air to flow therethrough but to block any air bubbles released from the low pressure water present in the lower portion of the cylinder 8 that is the portion beneath the piston 16 following return of the piston 16 to its normal position. More specifically, the screen is of a mesh such that air bubbles floating to the surface of the low pressure water will not pass through the screen into the adjacent portions of the inlet 51 and interfere with the formation of an ice plug of the desired size and volume within this passage. As a result, the entire passage 50 contains the same volume of water during each cycle of operation of the ice maker thereby assuring the formation of ice plugs of uniform size and volume and hence consistent delay periods in each ejection cycle.

While there has been shown and described a specific embodiment of the present invention it will be understood that it is not limited thereto and is intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An automatic ice maker comprising:
a refrigerated mold including an ice cavity and a cylinder having an upper portion spaced from said cavity by a wall,
said wall having an opening therein connecting said cavity and cylinder,
a piston in said cylinder movable from a normal position adjacent but spaced from the lower end of said cylinder to a raised position,
water supply means for introducing a measured volume of water under pressure into the bottom of said cylinder below said piston,
means operable upon movement of said piston to its raised position by the presence of said volume of water for ejecting an ice piece from said cavity,
means including a passage in said piston for conducting water from said cylinder into said opening, said passage having its inlet end in the lower end of said piston,
water in said passage and between said cylinder and piston surfaces being frozen during formation of an ice piece in said cavity,
means for preventing the flow of water from said cylinder into said ice cavity through said opening and to relieve the water pressure on said piston,
means for returning said piston to its normal position, and
means within the inlet end of said passage for preventing air liberated from the low pressure water remaining in the space in said cylinder below said piston following return of said piston to its normal position from entering said passage.

2. The ice maker of claim 1 in which said means within the inlet end of said passage comprises a wire mesh screen.

3. The ice maker of claim 2 in which the mesh of said screen prevents the passage of air liberated from said low pressure water but allows the passage of said air and high pressure water upon said melting of water in said passage.

References Cited by the Examiner

UNITED STATES PATENTS

2,763,996 9/1956 Lees ------------------ 62-353 X

ROBERT A. O'LEARY, Primary Examiner.
W. E. WAYNER, Assistant Examiner.