Nov. 23, 1965 K. L. NELSON 3,218,824

DIAPHRAGM ACTUATED CONTROL VALVES FOR AN ICE MAKER

Filed April 23, 1962 3 Sheets-Sheet 1

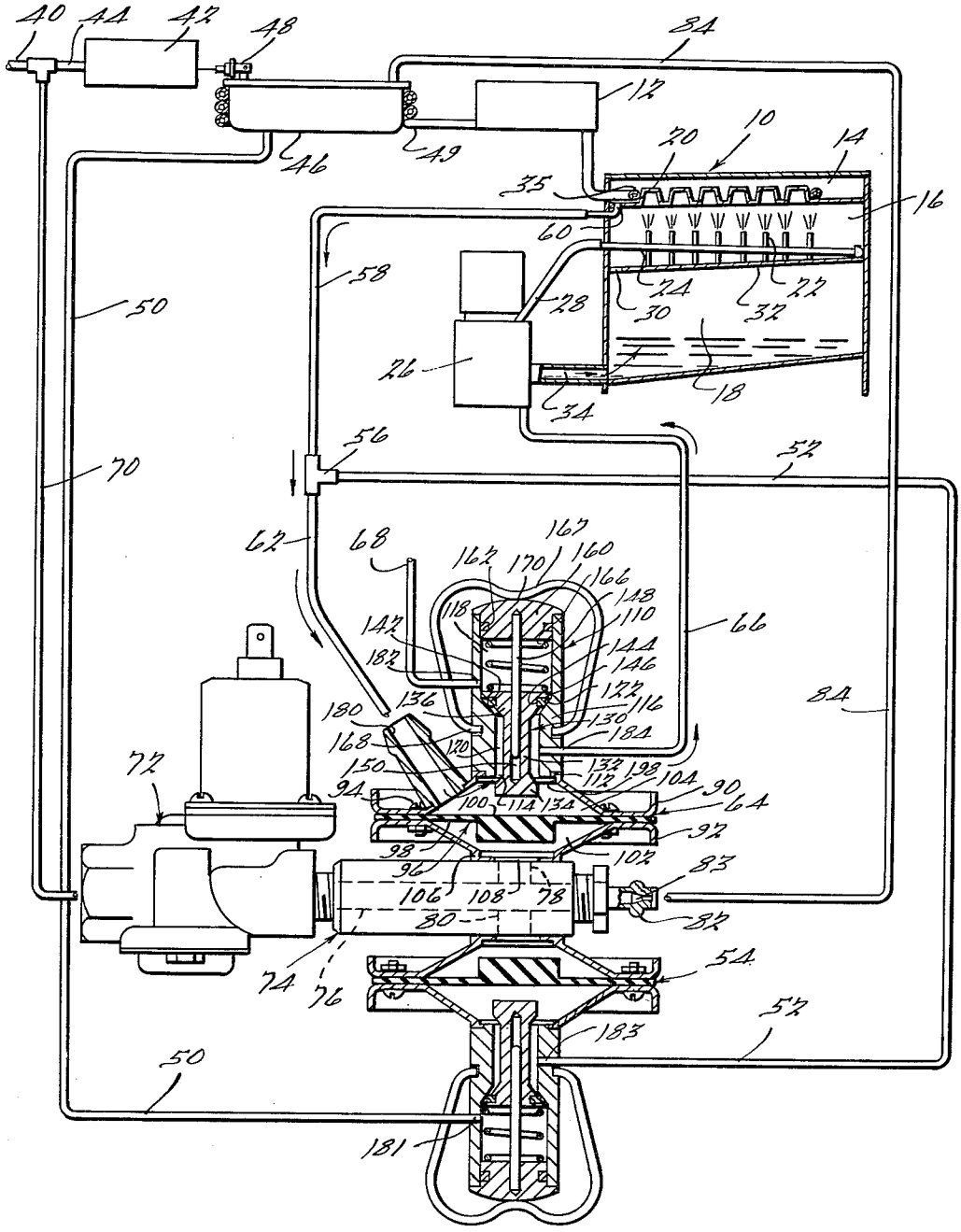

FIG. 1.

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Filed April 23, 1962 3 Sheets-Sheet 2

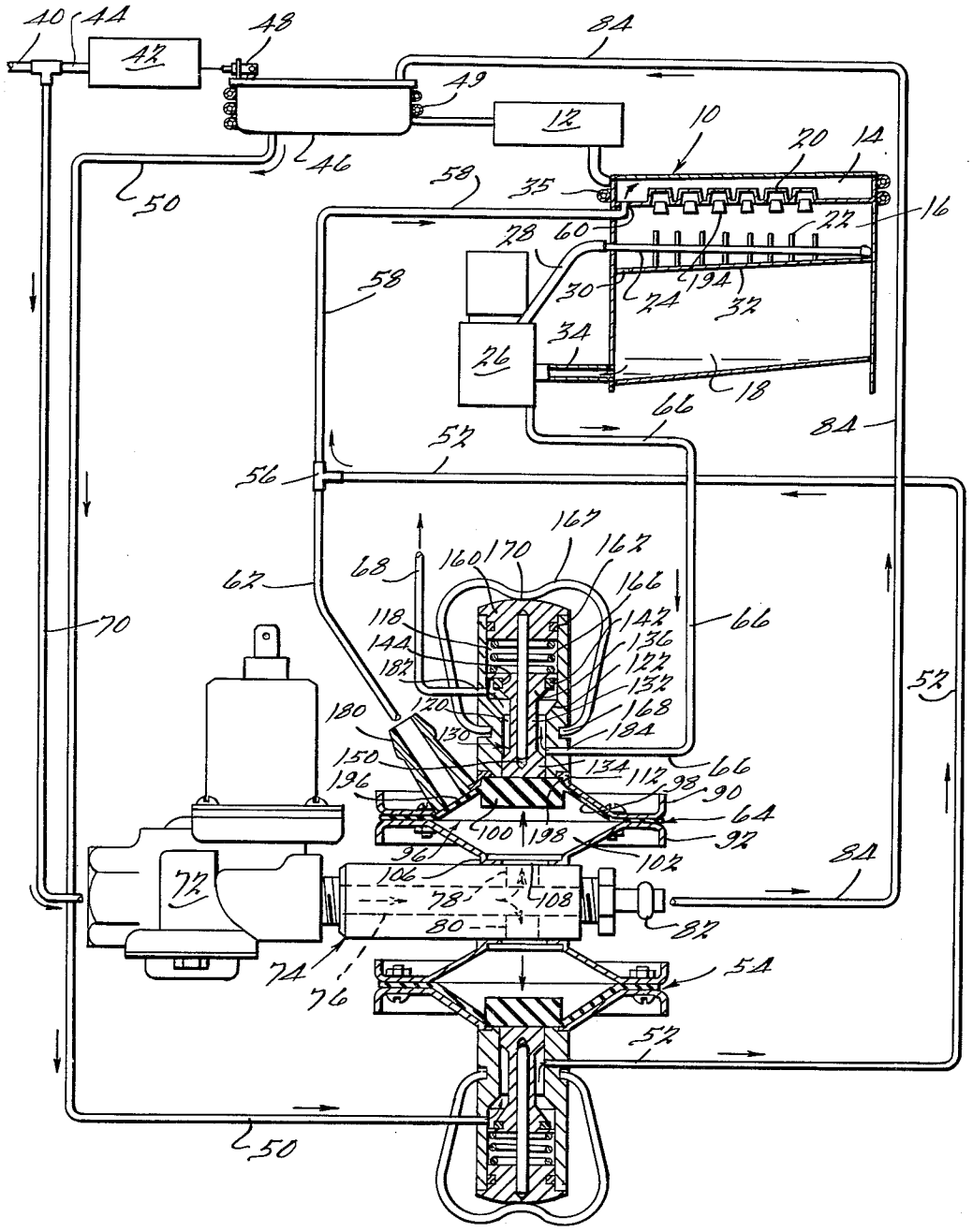

FIG. 2.

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DIAPHRAGM ACTUATED CONTROL VALVES FOR AN ICE MAKER

Filed April 23, 1962 3 Sheets-Sheet 3

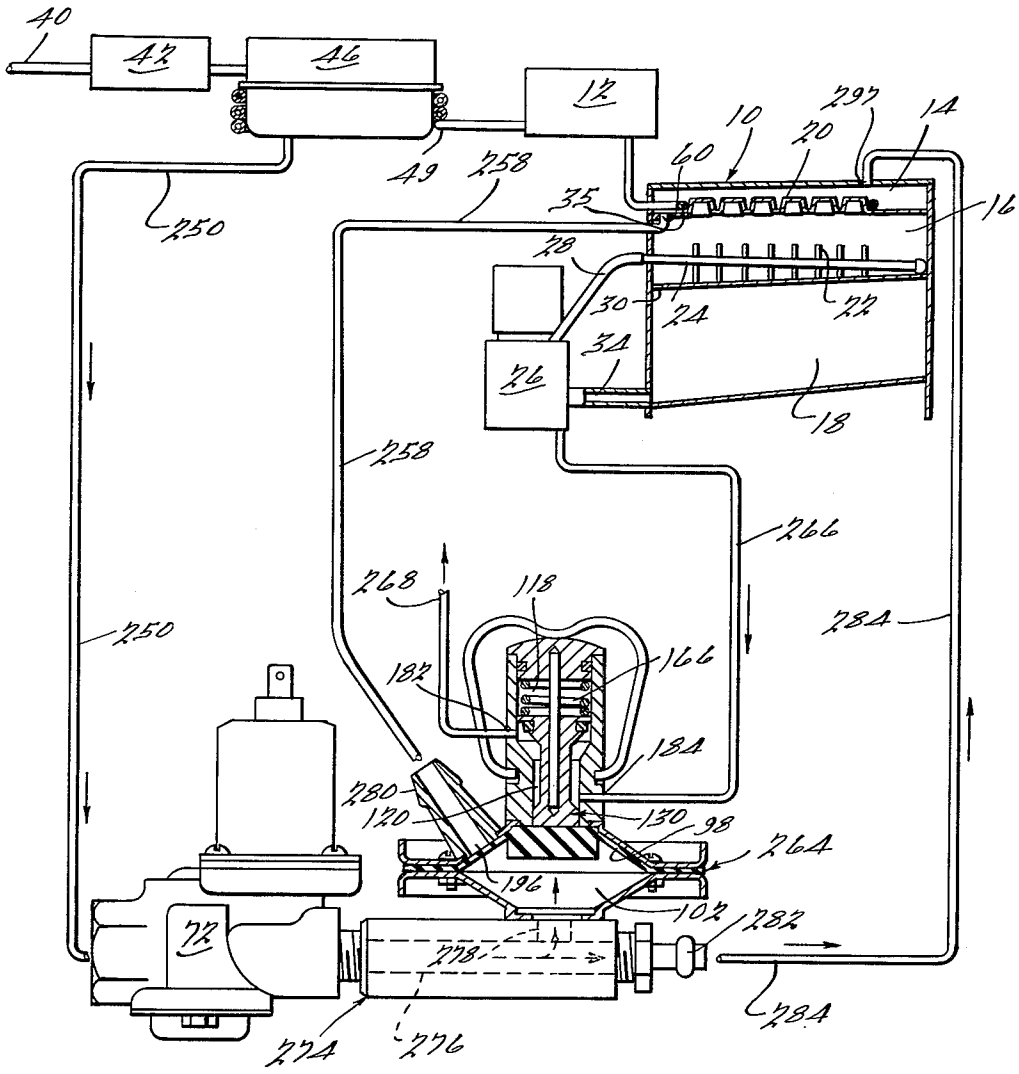

Fig. 3.

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DIAPHRAGM ACTUATED CONTROL VALVES FOR AN ICE MAKER

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Filed Apr. 23, 1962, Ser. No. 189,439
16 Claims. (Cl. 62—348)

This invention relates to the manufacture of ice cubes or the like, and more particularly to a water circulating system for association with ice cube manufacturing apparatus.

Conventional ice cube manufacturing apparatus usually includes an ice cube tray means having individual cube-forming cups, pipe means to deliver water to the cups for freezing therein, refrigerating means to freeze the water in the cups, release means to release the ice cubes formed in the individual cups, and collection means to collect and store the ice cubes. In ice cube vending machines and the like, it is desirable to provide apparatus which is automatic in operation, has a minimum of moving parts subject to wear and deterioration in use, and is reliable over long periods of use without observation or maintenance. This invention is specifically directed to improvements in the manufacture of ice cubes in automatic vending machines and the like by the provision of a new and improved water circulating system therefor.

One of the objects of this invention is to provide a new and improved system of supplying water to ice cube making apparatus.

Another object is to provide new and improved valve means for controlling water circulation in an ice cube making system.

Still another object is to provide a water circulating system for use with ice cube manufacturing apparatus wherein tap water is supplied for freezing to make ice cubes and heated tap water is supplied for releasing frozen ice cubes from cube forming cup means.

A further object is to provide a water circulating system for ice vending machinery having a minimum of control elements and wherein multiple flow paths for delivery of water to various destinations are obtainable through actuation of a single solenoid operated control valve.

Still a further object is to provide a water flow control means which is responsive to changes in water pressure to obtain a plurality of varying flow conditions which result in automatic cycling of various ice cube manufacturing processes or steps.

Another object is to provide a novel operational sequence for the manufacture of ice cubes or the like, and a novel system for obtaining a preferred operational sequence.

Other objects and some of the advantages of the system will be hereinafter described by reference to the following detailed description of illustrative embodiments of the present invention shown in the accompanying drawings wherein:

FIGURE 1 is a side elevational view, partly diagrammatic and partly in section, of one form of the present invention;

FIGURE 2 is another side elevational view, partly diagrammatic and partly in section, of the system shown in FIGURE 1 in another operational condition; and

FIGURE 3 is a side elevational view, partly diagrammatic and partly in section, of another form of the present invention.

Referring now to FIGURES 1 and 2, the novel system of the present invention is shown diagrammatically except for novel valve means associated therewith. It is to be understood that the subject system is adapted to be incorporated in an ice cube making device comprising a cabinet having an ice cube manufacturing portion, a storage bin for storing manufactured ice cubes, appropriate motor means for operating the manufacturing apparatus, conventional pump mechanism for delivering water through the water circulating system hereinafter described, conventional refrigerating apparatus including a compressor and condenser coils, and other suitable accessories including water pipe lines and coupling elements.

In the drawings, the ice cube manufacturing compartment is illustrated generally at **10** and the refrigerant compressor is shown at **12**. The ice cube manufacturing compartment is divided into an evaporator section **14**, a spray chamber **16**, and a sump **18**. A plurality of inverted ice cube forming cups **20** are provided between the evaporator chamber **14** and the spray chamber **16**, and open downwardly into the spray chamber. A plurality of upwardly facing spray nozzles **22** are mounted in the spray chamber **16** and are connected in any suitable manner to pipe means **24** through which water is delivered to the spray nozzles from a conventional pump **26** and a connecting line **28**. The nozzles may be mounted directly on top of the pipe means **24** or laterally offset and connected by an elbow or the like or movably mounted. A plurality of drain passages **30** may be provided in the bottom wall **32** of the spray chamber to permit excess water collecting therein to drain into the sump **18**. The sump **18** is connected to the pump **26** by a suitable passage **34** so that water may be delivered from sump to the spray nozzles by the pump.

The freezing cycle comprises the sprayed application of water from the sump **18** through the spray nozzles **22** to the surfaces of the cups **20**. The cups **20** are maintained at a temperature below the freezing point of the water by refrigerant passing through the coils **35** in a conventional manner the coils **35** may be located in heat transfer relationship with the cups **20** in any suitable manner, and are illustratively shown inside the compartment **10** in FIGS. 1 and 3 and outside the compartment **10** in FIG. 2. The application of the water spray to the cup cavities builds up ice therein until the cups are completely filled and ice cubes have been formed. At such time, the pump **26** and refrigerating system are deactivated, and ice cube releasing means are actuated to release the ice cubes from the cups. The release means utilized by the present invention comprises the application of heated water to the outer surfaces of the cups **20** in the evaporator chamber **14**. The heated water is adapted to circulate about the ice cups **20** and release the ice cubes formed therein. The ice cubes fall by gravity into the spray chamber **16** and are removed therefrom in a conventional manner by sloping chute means (not shown). Since this invention is directed particularly to the delivery of water spray for manufacturing the ice cubes and heated water for releasing the formed cubes, the other components of the apparatus will not be shown or described in detail.

A water inlet pipe **40** from a suitable supply source is connected to a conventional pressure regulating device **42** through a length of pipe **44**. The pressure regulator **42** supplies water to tank means **46** through a conventional float valve **48** or the like, which maintains a predetermined quantity of water in the tank. Refrigerant coils **49**, shown only partially and diagrammatically, of the compressor **12** may be wound around the tank **46**, or otherwise associated therewith, to provide means to heat the incoming water. Although the use of the refrigerant coils to heat the water provides a particularly beneficial result, other heating means may be employed if desired. An inlet line **50** connects the tank **46** to a line **52** through a valve means indicated generally at **54**. The line **52** is connected through suitable coupling means **56** to a line **58** which

communicates with the evaporator chamber **14** at **60**. The line **52** also communicates with the sump **18** through a line **62**, a valve means indicated generally at **64**, a line **66**, and the pump **26**. The valve means **64** controls communication between the lines **62**, **66** and between the line **66** and a drain line **68** which is connected to a suitable drain.

A line **70** containing water at line pressure incorporates flow control means for controlling flow through the lines previously described. The flow control means comprises a conventional solenoid actuated valve unit **72** through which the line **70** is connected to a coupling element **74**. The valve unit **72** controls flow of water into a central passage **76** and a pair of cross passages **78**, **80** which communicate with suitable control chambers provided in the valve means **54**, **64**. The other end of the passage **76** is connected through a restrictor member **82** having an orifice **83** therein and a return bleed line **84** to the tank **46**. The solenoid valve **72** is operable at predetermined times between open and closed positions. In the open position, water at line pressure from the line **40** is admitted into the element **74** to actuate the valve means **54**, **64**. In the closed position, water is prevented from entering the element **74** and the valve means **54**, **64** are deactuated.

Each of the valve means **54**, **64** are substantially identical in construction and therefore only the valve means **64** is hereinafter described in detail. In those instances where there are variations in construction or operation, the variations will be discussed in detail. The valve means includes a valve actuating portion comprising upper and lower shell portions **90**, **92** which are secured together by suitable fastening means **94** to form a diaphragm cavity indicated generally at **96**. The shell portions clampingly receive a diaphragm element **98** having an enlarged central section **100**. The diaphragm divides the cavity **96** into a control chamber **102** and a flow chamber **104**. The lower shell **92** is provided with a coupling boss **106** which is securely fastened to the connecting element **74** in any conventional manner such as by cooperating pipe threads or welding to connect a centrally located inlet passage **108** with the transverse passage **78**.

A valve housing **110** is secured to the upper shell **90** on a coupling boss **112** oppositely located from the boss **106** and having a suitable opening **114** provided therein. The valve housing **110** comprises a central body portion **116** having concentric central bores **118**, **120** of varying diameter which are connected by a conical valve seat portion **122**. The diameter of bore **120** is smaller than the diameter of bore **118** and is adapted to slideably receive a plunger valve **130** which comprises a central cylindrical portion **132** having oppositely extending conical headed portions **134**, **136** at each end. The conically headed portion **136** is provided with seal means in the form of a deformable washer **142** or the like, which is retained in an annular slot **144** and adapted to seat and form a seal on the conical seat **122**. A guide flange **146** is formed on the outermost end of the conical head **136** and is cooperatively spaced closely adjacent the inner periphery of the bore **118**. In order to further guide and space the plunger valve in the bore **120**, a guide stem **148** is slideably received in a guide stem bore **150** in the plunger valve at one end and is fixedly mounted in a cap element **160** at the other end.

The cap element **160** is adapted to be mounted in and close the bore **118**. A sealing means **162** is provided to seal the bore **118**. A spring element **166** is mounted in the bore **118** between the cap **160** and the upper flange **146** of the valve plunger to exert a valve closing force tending to seat the washer means **142** on the valve seat **122**. A wire latch **167** is pivotally mounted on the body **116** at **168** and has an abutment portion adapted to abut the cap **160** at **170** to secure the cap, spring, and valve in assembled position. The valve means **54** is identical to the valve means **64** except as hereinafter described.

The various water pipes are connected to the valve means by nipple type fittings such as shown at **180** for connecting to the line **62**. The fitting **180** communicates with the flow chamber **104**. Similar fittings (not shown) connect the drain line **68** to bore **118** and **182** and line **66** to bore **120** at **184** in the valve body **116**. The valve means **54** differs from valve means **64** in construction in that only lines **50** and **52** are connected through the valve. The line **52** corresponds to line **66**, and line **50** corresponds to line **68** as far as location of connection to the valve means is concerned.

The operation of the embodiment of FIGURES 1 and 2, with the parts in the position shown in FIGURE 1, is hereinafter described. The functions of identical parts of both of the valves **54**, **64** are described by single reference characters related only to valve **64**; and it is to be understood that corresponding parts of valve **54** are also being identified. When the solenoid valve **72** is closed, no water enters the passage **76** or the control chambers **102** to exert pressure on the diaphragms. Consequently, the diaphragms **98** are in a central or neutral position and the valve springs **166** maintain the valve plungers **130** in a fully extended position with the washer means **142** in sealing engagement with the conical seats **122**. In this position, the line **62** is connected to the line **66** through the flow chamber **104** and the bore **120**. A quantity of water remains in the evaporator chamber **14** and the sump **18** is empty from previous operations as will be hereinafter described in detail. The water which had previously been supplied to the evaporator chamber **14** drains by gravity through the line **58**, the line **62**, the flow chamber **104** and bore **120** of valve means **64**, and the line **66** to the sump **18**. Consequently, a fresh supply of water is provided for each cube making operation. The pump **26** is actuated when the cycle changes and water fills the sump **18** and is forced through the line **28** and the pipe **24** to the spray nozzles **22**. The water is sprayed into the inverted cups **20**, which are refrigerated by coils **35**, and ice cubes are formed therein. Excess water dripping downwardly from the cups **20** passes through suitable drain openings **30** back into the sump. The passage of water through lines **66**, **68** and **50**, **52** is prevented by a seal effected by the washer means on the valve plungers being urged into engagement with the conical valve seats by the associated spring means.

After a suitable time cycle during which the ice cubes have been completely formed, the pump **26** is deactivated and the solenoid valve **72** is actuated to open the line **70** to the central passage **76** as shown in FIGURE 2. Water at line pressure enters the passage **76**, and a pressure build-up is created by the restrictor **82**. The transverse passages **78**, **80** and the diaphragm control chambers **102** are filled with water under pressure to cause displacement of the diaphragms **98** upwardly into engagement with the adjacent conical heads **134** of the valve plungers. The valve plungers are thereby moved outwardly in the respective valve passages to unseat the washer members **142** from the conical seats **122** against the bias of the compression springs **166**. When the valve plungers have been opened, the line **66** is connected to the drain line **68** through bores **118**, **120** in valve means **64**, and the inlet water line **50** is connected to the line **52** through corresponding bores in valve means **54**. Excess water from the sump **18** drains through the line **66**, and the bores **118**, **120** in the valve means **64** to the drain line **68**. Heated water flows by gravity from the tank **46** through the line **50**, the valve means **54**, and the lines **52**, **58** to the evaporator chamber **14**. The water is heated in the tank **46** during the refrigerating cycle by the heat removed from the refrigerant in the coils **50** of the compressor **12**. The heated water flows by gravity to the evaporator chamber **14** and surrounds the ice cube forming cups **20**. The ice cubes **194** are thereby released and fall downwardly into the spray chamber **16** where they are collected and removed in a conventional man-

ner. The movement of the diaphragms in response to water pressure in the control chambers **102** serve the dual purpose of actuating the valve plungers and sealing off the line **62** and bore **120** from the flow chamber **104**. The diaphragm **98** has the dual function of actuating the valve plunger **130** and sealing the inlet **196** of the nipple connection **180** and the end of bore **120**. To this end, the enlarged portion **100** of the diaphragm is adapted to be received on a seat **198** formed in the shell.

After a suitable time interval, the solenoid valve **72** is deactivated and the water pressure in diaphragm chambers **96** is reduced by discharge of the water therein through the orifice **83** in the restrictor **82** so that the diaphragms return to their central positions and the valve plungers are once again seated on the valve seats **122**. At this time, the water remaining in the evaporator chamber **14** flows by gravity through the line **58**, the line **62**, through the valve means **64**, and the line **66** to the sump **18** to provide a fresh supply of water for the next freezing cycle as hereinbefore described. Although the water was originally at an elevated temperature when it entered the evaporator chamber, the temperature will be substantially lowered during release of the ice cubes and the water will be cool when subsequently delivered to the sump **18**. It should be understood that in arranging the apparatus of the present circulating system within the ice cube vending machine cabinet, the tank **46** is mounted at a higher elevation than the evaporator chamber **14**, and the sump **18** is mounted at a lower elevation than either the tank **46** or the evaporator chamber **14**.

An alternative embodiment is shown in FIGURE 3 wherein the number of parts required for the system is further minimized by eliminating one of the valve means, such as **54**. In this system, heated water is delivered from a pressurized tank **46** which is connected directly to the inlet water line **40**. The heated water is carried to the evaporator chamber **14**, through a line **250**, the solenoid control valve **72**, a coupling element **274**, flow restrictor means **282**, and a line **284**. A central passage **276** is provided in the connecting element and a cross passage **278** communicates with the control chamber **102** of the valve means **264**. A line **266** connects the sump **18** to the valve means at **184** and a line **258** connects the evaporator chamber **14** to the valve means at **280**. A drain line **268** is connected to the valve means at **182**.

When the solenoid valve **72** is actuated, as shown in FIGURE 3, heated water flows from the pressure tank **46** through line **250**. The water fills the diaphragm control chamber **102** and the pressure build-up created by the restrictor **282** actuates the diaphragm upwardly to move the valve plunger **130** outwardly against the bias of the compression spring **166**. The drain passage **268** is thereby connected to the sump line **266** through valve bores **118, 120**. The diaphragm simultaneously seals inlet passage **196** and the end of bore **120**. Consequently, excess water in the sump **18** drains through the drain line **268**. Simultaneously, the heated water in tank **46** passes through the supply lines **250, 276** and **284** to the evaporator chamber **14** at **297** and heats the outer surfaces of the ice cube cups to release the formed ice cubes. The evaporator chamber drain passage **258** which is provided to carry water from the evaporator chamber to the sump is closed by the diaphragm. When the solenoid valve **72** is deactivated to close the line **250**, the diaphragm **98** returns to its central position and water flows from the evaporator chamber **14** through the line **258**, the bore **120** of valve means **264** and the supply line **266** to the sump **18**.

A water circulation system has thus been provided for the manufacture of ice cubes having a freezing cycle and a harvesting cycle wherein the water is sprayed into refrigerated ice cube forming cups in one instance and wherein heated water is applied over the outer surfaces of the cups to release the formed ice cubes in another instance. The water utilized in forming the ice cubes is cyclically replenished by a fresh supply. Since a given quantity of water is used for the dual purposes of releasing the ice cubes and replenishing the supply of spray water, a minimum amount of water is wasted and the number of supply lines and control valves required are minimized. The whole system is controlled in effect by the simple "on-off" operation of the solenoid valve **72**. The control valve means **54, 64** and **264** are directly and positively responsive to the existence of water line pressure controlled by the solenoid valve **72** and effect positive and precise control of flow through the various water lines in the system. It should be readily appreciated that the system is comparatively quiet in operation and that a minimum of maintenance and repair is required.

The described modifications, and other variations in the construction and arrangement of the parts which embody the inventive principles hereinbefore disclosed, are intended to be included within the scope of the invention as defined by the appended claims.

What is claimed is:

1. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, cup means for forming ice cubes, refrigerating means to freeze water in said cup means, pump means to deliver water to said cup means for freezing therein to manufacture ice cubes, sump means to hold a quantity of water to be delivered to said cup means by said pump means, release water tank means surrounding said cup means for holding a quantity of heated water in contact with the outer surfaces of said cup means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said cup means and release ice cubes formed therein, drainage means to drain and dispose of water remaining in said sump means after ice cubes have been formed in said cup means, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice cubes in said cup means have been released and after said sump means has been drained to provide a fresh supply of water for delivery to said cup means during the next formation of ice cubes, flow control means controllably associated with said heated water delivery means, said drainage means, and said sump replenishing means to control the flow of water in said system in a predetermined sequence, pressure responsive actuating means for actuating said flow control means and being connected to said source and operable by water pressure to actuate said flow control means, and means to vary the water pressure acting on said pressure responsive means.

2. In apparatus for controlling flow of water through multiple flow paths, in an ice manufacturing system, an inlet water line in said system, a diaphragm housing, a flexible diaphragm mounted in said housing for movement therein from a normal position to a distended position, said diaphragm dividing said housing into two chambers and closing said chambers from one another, a control port connecting one of said chambers to said inlet water line to deliver diaphragm controlling water thereto, water pressure varying means in said inlet water line to vary the water pressure in said one of said chambers and displace said flexible diaphragm between said normal position and said distended position, a plurality of controlled water ports communicating with the other of said chambers, valve means controllably associated with said controlled water ports to control communication between said controlled water ports, and said valve means being operably associated with said diaphragm whereby movement of said diaphragm in response to changes in pressure of the controlling water in said one of said chambers causes corresponding displacement of said valve means to control water flow through said controlled water ports.

3. In a valve arrangement for controlling fluid flow in a plurality of fluid passages in response to the presence or

absence of fluid pressure in a control passage and comprising; at least three fluid passages, flow passage means connecting said three fluid passages, restrictor means to create a pressure build-up in said control passage, a diaphragm means movably responsive to pressure changes in said control passage, valve means to connect one of said fluid passages alternately to the other of said fluid passages, said valve means being actuated in response to movement of said diaphragm means, said flow passage means comprising a central passage portion of reduced diameter connecting enlarged end passage portions, one of said end passage portions communicating directly with said diaphragm means, a valve seat surface connecting the other of said end passage portions to said central passage portion, said valve means comprising a plunger member slideably received within said flow passage means, said plunger having a pair of head portions separated by a reduced center portion of smaller cross section than said central passage portion of said flow passage means, one of said head portions having a surface adapted to provide a seal with said valve seat surface to close off said other of said end passage portions, the other of said head portions being cooperable with said diaphragm means to close off said one of said end passage portions, and one of said fluid passages intersecting said central passage portion and the other of said fluid passages intersecting said enlarged passage portions whereby flow may be alternately established between said one of said fluid passages and one or the other of said other of said fluid passages.

4. An ice cube making fluid control system for use in ice cube making machinery including a source of inlet water, means to heat said inlet water, a refrigerating system, ice cube forming receptacles, a water reservoir surrounding said receptacles, a pump for delivering water to said ice cube forming receptacles, a water reservoir for said pump, and drain means to remove water from said system, said fluid control system comprising: water inlet passage means, an on-off type inlet water control valve associated with said water inlet passage means for controlling flow of water therethrough, first passage means connected to said inlet passage means at one end and communicating at the other end with said water reservoir surrounding said ice cube receptacles, system controlling valve means located downstream of said inlet water control valve and being associated with said first passage means, said system controlling valve means being responsive to said first passage means, a second passage means connecting said water reservoir for said pump and said drain means, third passage means connecting said water reservoir for said pump and said water reservoir surrounding said ice cube forming receptacles, said system controlling valve means being controllably connected to each of said second and third passage means, said system controlling valve means being adapted to alternately direct flow of water through said second passage means from said water reservoir for said pump to said drain means or through said third passage means from said water reservoir surrounding said ice cube forming receptacles to said water reservoir for said pump depending on the condition of said inlet water control valve, the pressure of inlet water downstream of said inlet passage control valve in said first passage means when said inlet water control valve is open being adapted to actuate said system controlling valve means and connect said water reservoir for said pump means to said drain means while heated inlet water flows through said first passage means to said water reservoir surrounding said ice cube forming receptacles to release ice cubes formed in said receptacles, and the absence of pressure of inlet water downstream of said inlet water control in the closed position thereof being operable to actuate said system controlling valve means to a position connecting said water reservoir surrounding said ice cube receptacles with said water reservoir for said pump whereby water accumulated in said water reservoir surrounding said ice cube forming receptacles flows to said water reservoir for said pump to replenish the water previously delivered to said drain means.

5. In an ice cube manufacturing device having ice cube forming means, a water supply system comprising: a source of water, means to heat inlet water from said source, a water reservoir surrounding said ice cube forming means, an on-off control valve to control flow of heated inlet water from said source through a passage to said water reservoir in the on position, pump means for pumping water to said ice cube forming means, an inlet water pipe connecting said source of water to said water reservoir surrounding said ice cube forming means, an inlet water pressure responsive valve means connected to said inlet water pipe, a pump line extending from said water pressure responsive valve means to said pump means, a drain line extending from said valve means to a drain, a water supply line extending from said water reservoir surrounding said ice cube forming means to said valve means, said water pressure responsive valve means being operable in the on position of said control valve whereat heated water flows to said water reservoir surrounding said ice cube forming means to close said water supply line extending from said water reservoir to said valve means and to connect said pump line to said drain line, and said valve means being further operable in response to the off position of said control valve to close said drain line and to connect said water supply line to said pump line to permit water to flow from said water reservoir surrounding said ice cube forming means to said pump means for delivery to said ice cube forming means.

6. A water system for controlling the supply of water to ice cube manufacturing apparatus including an evaporator chamber, a spray chamber, a pump sump, refrigeration compressor means, and condenser coil means; the invention comprising a tank for storing a quantity of water, said condenser coils being associated with said tank to heat the water therein, an inlet line leading from said tank to said system, control valve means to control the flow of water from said tank to said system, a first line connecting said inlet line to said evaporator chamber, a second line connecting said evaporator chamber to said control valve means, a third line connecting said sump to said control valve means, a fourth line connecting said control valve means to drain means, and pressure responsive means connected to said inlet line and operable by pressure in said line for actuating said control valve means to one position to open said first line to admit heated water to said evaporator chamber and to close said second line to prevent flow of water from said evaporator chamber to said valve means and to open said third line to said fourth line to permit flow of water from said pump sump to said drain means, and for actuating said control valve means to another position to close said first line to prevent flow of heated water to said evaporator chamber and to open said second line and connect said third line thereto to permit flow of water from said evaporator chamber to said pump sump and to close said fourth line to prevent flow to said drain means.

7. In a water circulation system having multiple flow paths and associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, ice forming means for forming ice cubes, refrigerating means to freeze water in said ice forming means, pump means to deliver water to said ice forming means for freezing therein to manufacture ice cubes, sump means to store a quantity of water to be delivered to said ice forming means by said pump means, release water tank means surrounding said ice forming means for holding a quantity of heated water in heat transfer relationship with said ice forming means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat

said ice forming means and release ice cubes formed therein, drainage means to drain and dispose of water remaining in said sump means after ice cubes have been formed in said ice forming means, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice cubes in said ice forming means have been released and after said sump means has been drained to provide a fresh supply of water for delivery to said ice forming means during the next formation of ice cubes, flow control means controllably associated with said heated water delivery means, said drainage means, and said sump replenishing means to control the flow of water in said system in a predetermined sequence, said flow control means comprising; a diaphragm housing, a flexible diaphragm mounted in said housing for movement therein under pressure from a normal position to a distended position, said diaphragm dividing said housing into two chambers, a control port connected to one of said chambers to deliver diaphragm controlling water under pressure thereto, a plurality of controlled water ports communicating with the other of said chambers, water passage means connecting said drainage means and said sump replenishing means and said sump means to said controlled water ports, valve means controllably associated with said controlled water ports to control passage of water between said controlled water ports, and said valve means being operably associated with said diaphragm whereby movement of said diaphragm in response to changes in water pressure in said one of said chambers causes corresponding displacement of said valve means to control water flow through said controlled water ports.

8. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, cup means for forming ice cubes, refrigerating means to freeze water in said cup means, pump means to deliver water to said cup means for freezing therein to manufacture ice cubes, sump means to store a quantity of water to be delivered to said cup means by said pump means, release water tank means surrounding said cup means for holding a quantity of heated water in heat transfer relationship with said cup means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said cup means and release ice cubes formed therein, drainage means to drain and dispose of water remaining in said sump means after ice cubes have been formed in said cup means, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice cubes in said cup means have been released and after said sump means has been drained to provide a fresh supply of water for delivery to said cup means during the next formation of ice cubes, flow control means controllably associated with said heated water delivery means, said drainage means, and said sump replenishing means to control the flow of water in said system in a predetermined sequence, said flow control means comprising; a source of fluid under pressure in a line, solenoid means to control flow of said fluid through said line, a diaphragm housing, passage means connecting said diaphragm housing to said line downstream of said control means, restrictor means located downstream of said passage means to create a pressure build-up therein, a diaphragm mounted in said diaphragm housing for movement between a normal and a distended position in response to pressure build-up of said fluid, a valve housing having a passage connected to said diaphragm housing on the side of said diaphragm opposite the connection of said passage means thereto, movable valve means carried in said passage of said valve housing, said diaphragm being controllably associated with said valve means to cause displacement thereof during movement of said diaphragm between said positions, a plurality of flow ports connected to said passage of said valve housing at axially spaced intervals therealong, water passage means connecting said drainage means and said sump replenishing means and said sump means to said flow ports, and said movable valve means having means to alternately close and open said flow ports during displacement thereof.

9. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, cup means for forming ice cubes, refrigerating means to freeze water in said cup means, pump means to deliver water to said cup means for freezing therein to manufacture ice cubes, sump means to hold a quantity of water to be delivered to said cup means by said pump means, release water tank means surrounding said cup means for holding a quantity of heated water in contact with the outer surfaces of said cup means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said cup means and release ice cubes formed therein, drainage means to drain and dispose of water remaining in said sump means after ice cubes have been formed in said cup means, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice cubes in said cup means have been released and after said sump means has been drained to provide a fresh supply of water for delivery to said cup means during the next formation of ice cubes, flow control means controllably associated with said heated water delivery means, said drainage means, and said sump replenishing means to control the flow of water in said system in a predetermined sequence in response to the presence or absence of flow of fluid in a control passage, a plurality of fluid passages connecting said drainage means and said sump replenishing means and said sump means to said flow control means, flow passage means in said flow-control means connecting said fluid passages, restrictor means to create a pressure build-up in said control passage, a diaphragm means movably responsive to pressure build-up in said control pasage, valve means to connect one of said fluid passages alternately to the other of said fluid passages, said valve means being actuated in response to movement of said diaphragm means, said flow passage means comprising a central passage portion of reduced diameter connecting enlarged end passage portions, one of said end passage portions communicating directly with said diaphragm means, a valve seat surface connecting the other of said end passage portions to said central passage portion, said valve means comprising a plunger member slideably received within said flow passage means, said plunger having a pair of head portions separated by a reduced center portion of smaller cross section than said central passage portion of said flow passage means, one of said head portions having a surface adapted to provide a seal with said valve seat surface to close off said other of said end passage portions, the other of said head portions being cooperable with said diaphragm means to close off said one of said end passage portions, and one of said fluid passages intersecting said central passage portion and the other of said fluid passages intersecting said enlarged passage portions whereby flow may be alternately established between said one of said fluid passages and one or the other of said other of said fluid passages.

10. In a water circulating system associated with apparatus for manufacturing ice cubes, a plurality of water passages connected to a plurality of water utilization points in said water circulating system, flow control means connected in said water passages to control the flow of water in said system in a predetermined sequence, said flow control means comprising a source of fluid under pressure in a line, control means to control flow of said fluid through said line, a diaphragm housing, passage means connecting said diaphragm housing to said line downstream of said control means, restrictor means lo-

cated downstream of said passage means to create a pressure buildup therein, a diaphragm mounted in said diaphragm housing for movement between a normal and a distended position in response to pressure buildup of said fluid, a valve housing having a passage connected to said diaphragm housing on the side of said diaphragm opposite the connection of said passage means thereto, movable valve means in said passage of said valve housing, said diaphragm being controllably associated with said valve means to cause displacement thereof during movement of said diaphragm between said positions, a plurality of flow ports connected to said water passages and connected to said passage of said valve housing, and said movable valve means being movable to alternately close and open said flow ports to direct flow of water between said flow ports from certain ones of said water passages to other ones of said water passages.

11. In a water circulating system associated with apparatus for manufacturing ice cubes, a plurality of water passages connected to various parts in said water circulating system, flow control means connected to said water passages to control the flow of water in said system in a predetermined sequence in response to the presence or absence of pressure in a control passage, said flow control means comprising at least three water passages, flow passage means connecting said three water passages, restrictor means to create a pressure buildup in said control passage, a diaphragm means movably responsive to pressure buildup in said control passage, valve means to connect one of said water passages alternately to the other of said water passages, said valve means being actuated in response to movement of said diaphragm means, said flow passage means comprising a central passage portion of reduced diameter connecting an enlarged end passage portion, one of said end passage portions connected directly with said diaphragm means, a valve seat surface connecting the other of said end passage portions to said central passage portion, said valve means comprising a plunger member slidably received within said flow passage means, said plunger having a pair of head portions separated by a reduced center portion of smaller cross section than said central passage portion of said flow passage means, one of said head portions having a surface adapted to provide a seal with said valve seat surface to close off said other of said end passage portions, the other of said head portions being cooperable with said diaphragm means to close off said one of said end passage portions, and one of said water passages intersecting said central passage portion and the other of said water passages intersecting said enlarged passage portions whereby flow may be alternately established between said one of said water passages and one or the other of said other of said water passages.

12. In a water circulating system associated with apparatus for manufacturing ice cubes, water passage means interconnected in said water circulating system to deliver and remove water from various parts of said system, flow control means interconnecting certain of said water passage means to control the flow of water in said system in a predetermined sequence, said flow control means comprising: a diaphragm housing, a flexible diaphragm mounted in said housing for movement therein under pressure from a normal position to a distended position, said diaphragm dividing said housing into two separate chambers closed from one another, a control port connecting one of said chambers to a source of water under pressure to deliver diaphragm controlling water under pressure thereto, a plurality of controlled water passage ports connected to the certain ones of said water passage means and communicating with the other of said chambers, valve means controllably associated with said controlled water passage ports to control passage of water between said controlled water passage ports, and said valve means being operably associated with said diaphragm whereby movement of said diaphragm in response to changes in water pressure in said one of said chambers causes corresponding displacement of said valve means to control water flow through said control water passage ports.

13. In a water circulating system associated with apparatus for manufacturing ice cubes, a source of water, heated water delivery means to deliver heated water to release ice cubes formed by said apparatus, drainage means to drain and dispose of excess water following the formation of ice cubes by said apparatus, replenishing means to deliver the heated water after the ice cubes are released to provide a fresh supply of water for the next formation of ice cubes, flow control means controllably associated with said heated water delivery means, said drainage means, and said replenishing means to control the flow of water in said system in a predetermined sequence, pressure responsive actuating means for said flow control means connected to said source and operable by water pressure to actuate said flow control means, and means to vary the water pressure acting on said pressure responsive actuating means.

14. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, ice forming means, refrigeration means to freeze water in said ice forming means, pump means to deliver water to said ice forming means for freezing therein to manufacture ice, sump means to hold a quantity of water to be delivered to said ice forming means by said pump means, ice release water tank means for holding a quantity of heated water in heat transfer relationship with said ice forming means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said ice forming means and release ice formed therein, drainage means to drain and dispose of water remaining in said sump means after ice has been formed, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice has been released and after said sump means has been drained to provide a fresh supply of water for delivery to said ice forming means during the next ice forming cycle, an inlet water line connected to said inlet tank, solenoid actuated valve means controlling flow of water through said inlet water line, passage means connecting said heated water delivery means and said drainage means and said sump replenishing means, flow control means in said passage means and being connected to said inlet water line downstream of said solenoid actuated valve means, restrictor means located in said inlet water line downstream of said flow control means to create a pressure build-up, and pressure responsive means associated with said flow control means to actuate said flow control means between varying positions to obtain varying flow cycles in said heated water delivery means and said drainage means and said sump replenishing means in response to the presence or absence of water pressure in said inlet water line downstream of said solenoid actuated valve means.

15. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, ice forming means, refrigeration means to freeze water in said ice forming means, pump means to deliver water to said ice forming means for freezing therein to manufacture ice, sump means to hold a quantity of water to be delivered to said ice forming means by said pump means, ice release water tank means for holding a quantity of heated water in heat transfer relationship with said ice forming means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said ice forming means and release ice formed therein, drainage means to drain and dispose of water remaining in said sump means after ice has been

formed, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice has been released and after said sump means has been drained to provide a fresh supply of water for delivery to said ice forming means during the next ice forming cycle, an inlet water line connected to said inlet tank, solenoid actuated valve means controlling flow of water through said inlet water line, flow control means mounted downstream of said solenoid actuated valve means, valve plunger means in said flow control means movable between spaced positions and connecting said sump replenishing means with said drainage means in one spaced position and connecting said sump means to said sump replenishing means in another spaced position, pressure responsive diaphragm means associated with said flow control means and being movable between a normal position and a distended position in response to water pressure downstream of said solenoid actuated valve means to actuate said valve plunger means between the spaced positions to obtain varying flow cycles in said heated water delivery means and said drainage means and said sump replenishing means, control chamber means connected to said inlet water line downstream of said solenoid actuated valve means and being defined in part by said diaphragm means, spring means to maintain said valve plunger means in the one spaced position, and said diaphragm means being effective to move said valve plunger means to the other spaced position and simultaneously effect a seal between said drainage means and said sump replenishing means.

16. In a water circulation system associated with apparatus for manufacturing ice cubes, a source of water, an inlet tank for storing water from said source, heating means to heat water stored in said inlet tank, ice forming means, refrigeration means to freeze water in said ice forming means, pump means to deliver water to said ice forming means for freezing therein to manufacture ice, sump means to hold a quantity of water to be delivered to said ice forming means by said pump means, ice release water tank means for holding a quantity of heated water in heat transfer relationship with said ice forming means, heated water delivery means to deliver heated water from said inlet tank to said release water tank means to heat said ice forming means and release ice formed therein, drainage means to drain and dispose of water remaining in said sump means after ice has been formed, sump replenishing means to deliver the heated water from said tank means to said sump means after the ice has been released and after said sump means has been drained to provide a fresh supply of water for delivery to said ice forming means during the next ice forming cycle, an inlet water line connected to said inlet tank, solenoid actuated stop valve means mounted in said inlet line to alternately stop flow of water therethrough or permit full flow therethrough, connector tube means connected to said stop valve means downstream thereof and having passage means forming a continuation of said inlet line, transverse passage means extending from said passage means within said connector tube means, shell means connected to said connector tube means and defining a cavity in communication with said transverse passage means, diaphragm means separating said cavity into a flow chamber and a control chamber, said control chamber being connected to said transverse passage means, restrictor means to retard flow of water in said passage means and fill said control chamber with water under pressure and cause distention of said diaphragm means, valve bore body means connected to said flow chamber opposite said diaphragm means and having valve bore means provided therein, valve plunger means reciprocably mounted in said valve bore means, said valve plunger means being provided with portions adapted to alternately open and close portions of said valve bore means, said valve plunger means being connected to said diaphragm means for movement thereby in response to water pressure in said control chamber to close one portion of said valve bore and open another portion thereof, spring means associated with said valve plunger means to move said valve plunger means in a direction opposite to the movement caused by said diaphragm means and to normally maintain said valve plunger means in a position closing the other portion of said valve bore means, said drainage means being connected to said valve bore means and having flow thereto being controlled by said valve plunger means, said sump replenishing means being connected to said flow chamber and flow therefrom through said flow chamber being controlled by said valve plunger means, and means communicating with said sump means being connected to said valve bore means for alternate connection to said drainage means and said sump replenishing means.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,218,824 November 23, 196[illegible]

Kenneth L. Nelson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 5, for "and" read -- at --; column 7, line 48, after "to" insert -- the presence or absence of water pressure downstream of said inlet water control valve as determined by the condition of said inlet valve in --; column 14, line 22, for "to" read -- with --.

Signed and sealed this 11th day of October 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents