Dec. 18, 1962 D. A. COUNCIL ET AL 3,068,660

ICE MAKING MACHINE

Filed March 8, 1961 4 Sheets-Sheet 1

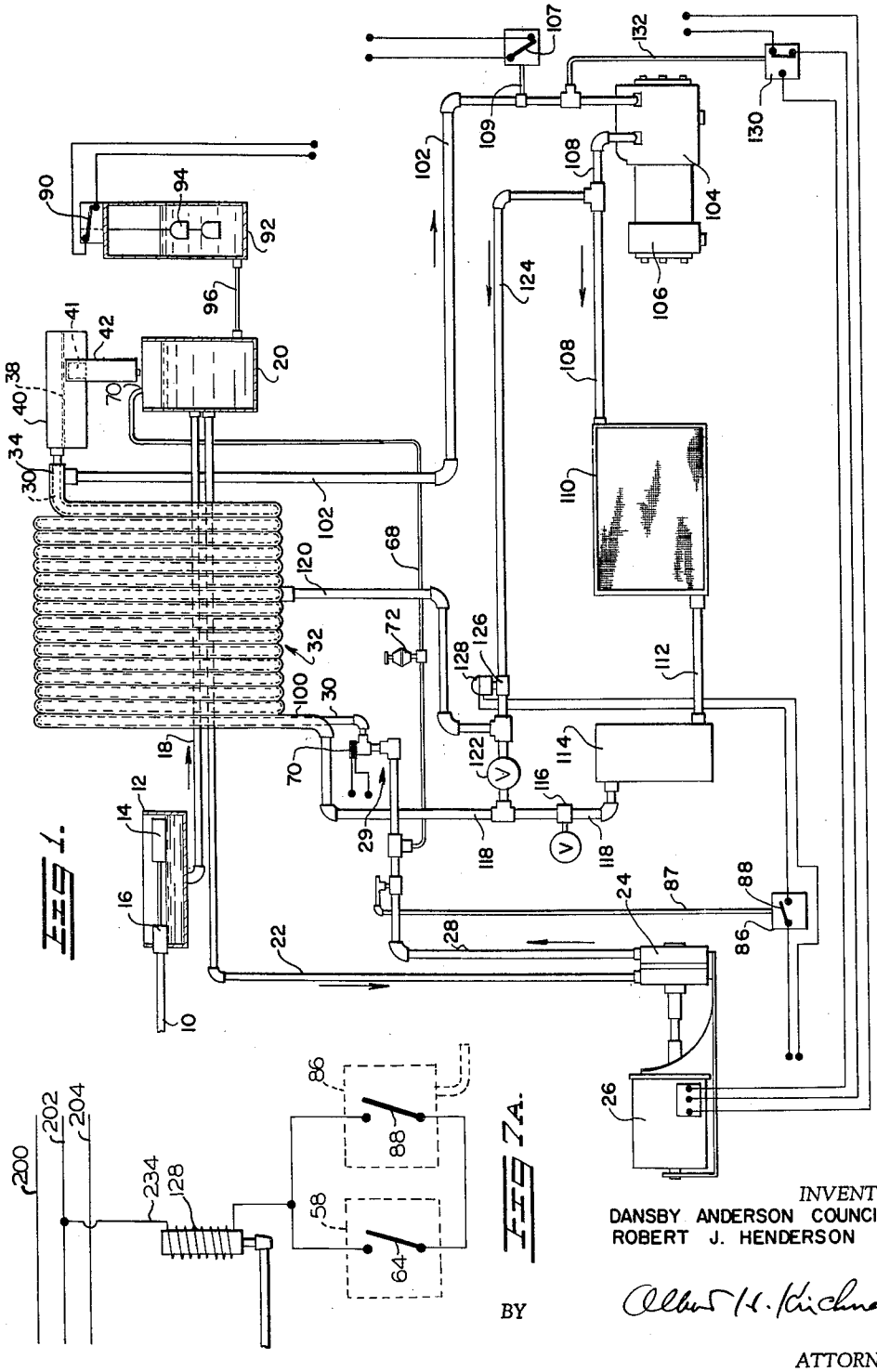

FIG. 1.

FIG. 1A.

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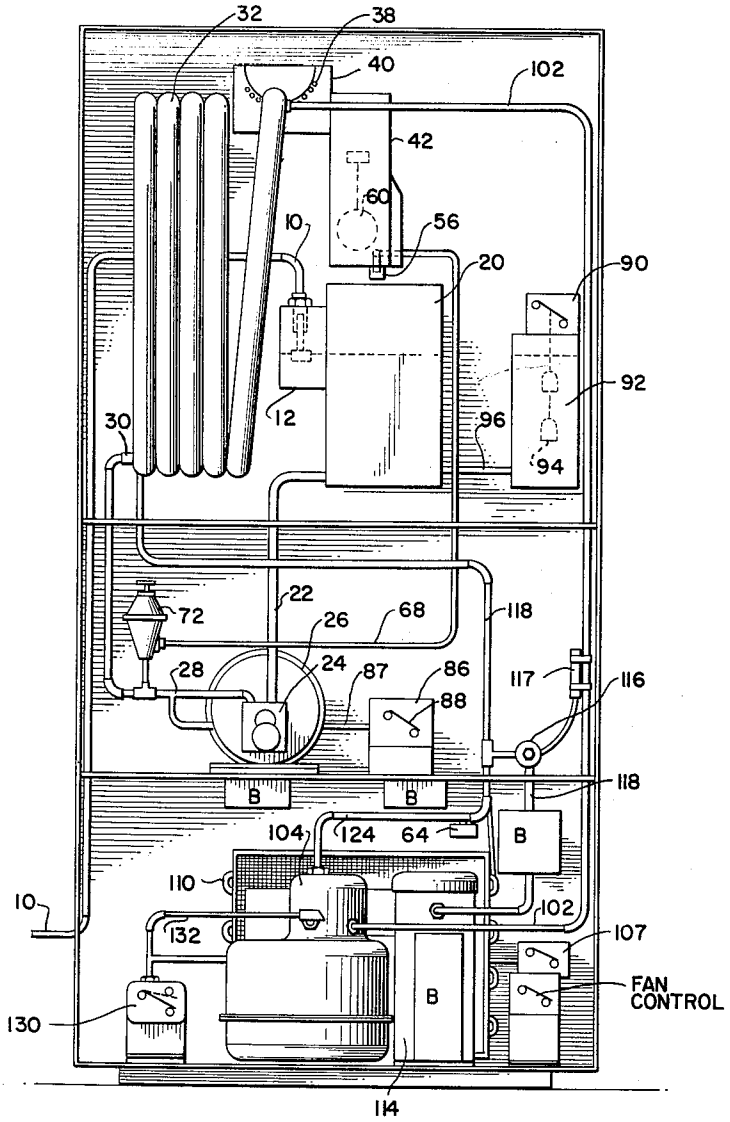
FIG 2



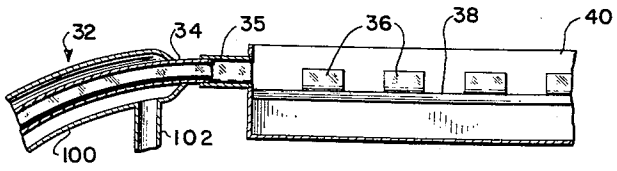


FIG 3

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ICE MAKING MACHINE

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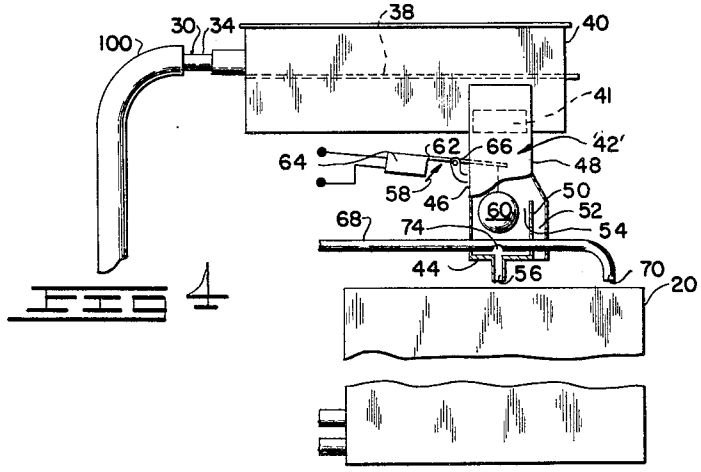

FIG. 4

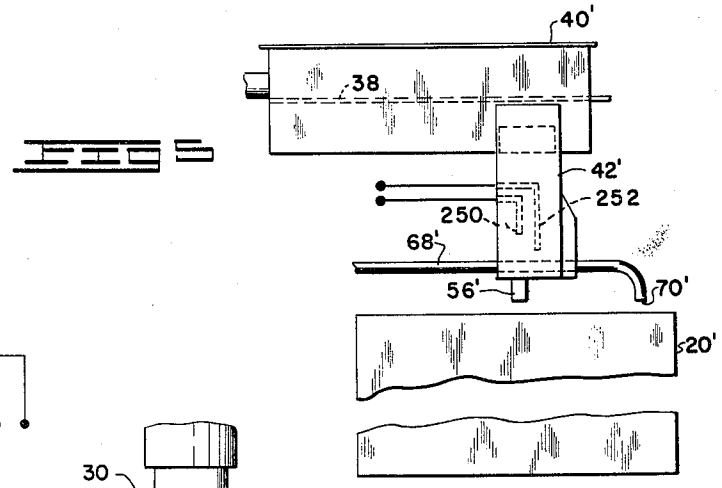

FIG. 5

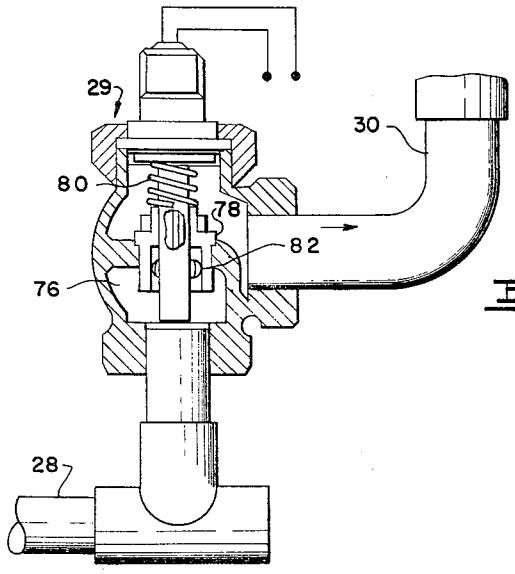

FIG. 6

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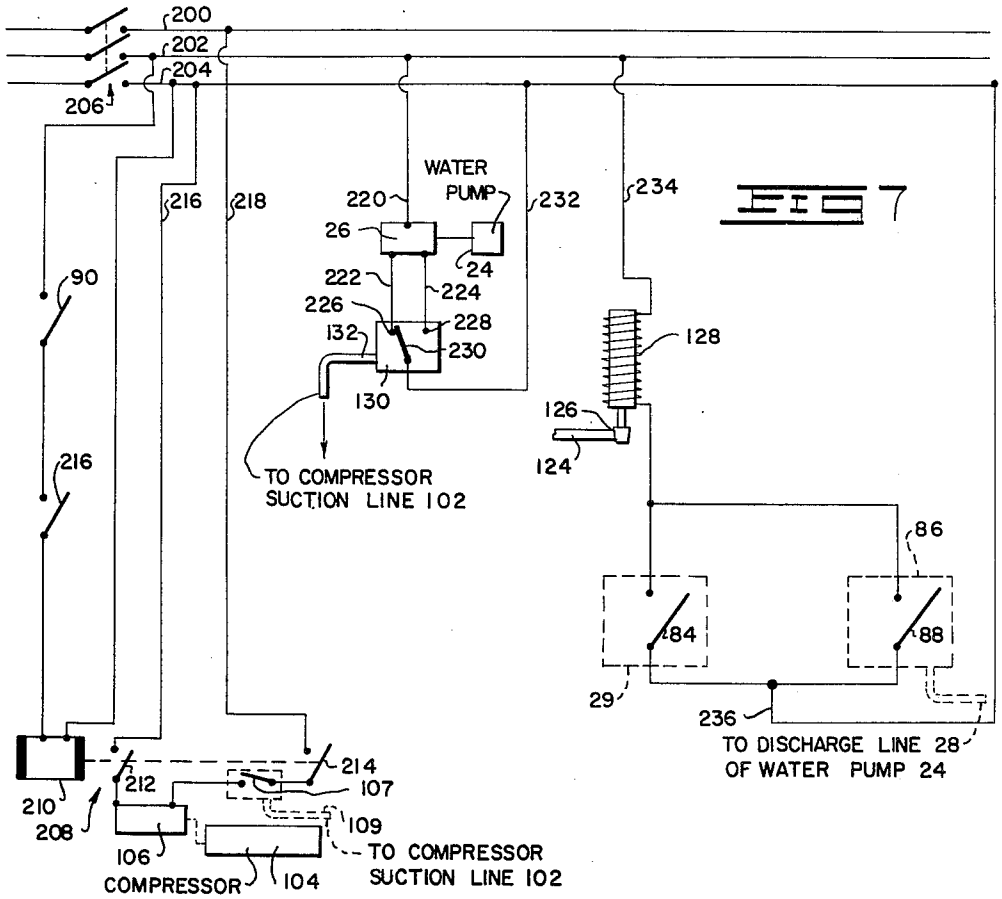

FIG 7

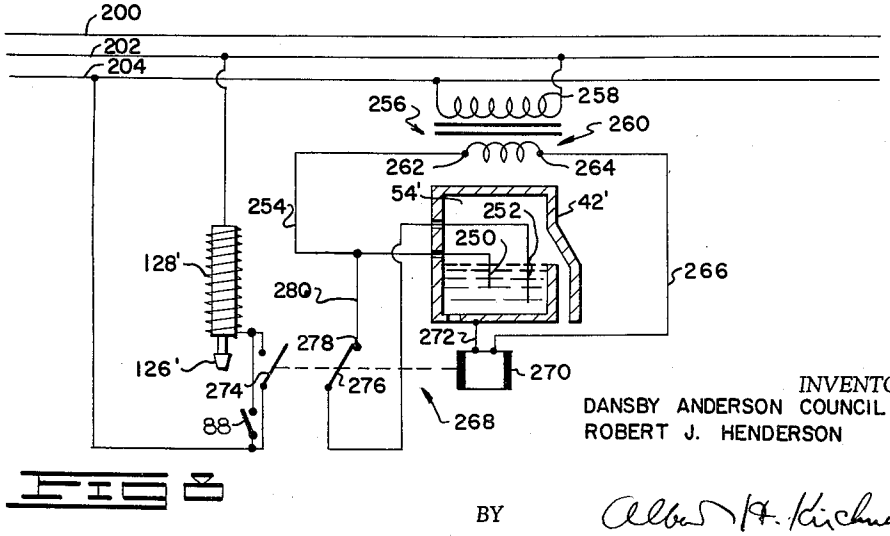

FIG 8

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United States Patent Office 3,068,660 Patented Dec. 18, 1962

3,068,660
ICE MAKING MACHINE

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Filed Mar. 8, 1961, Ser. No. 94,203
21 Claims (Cl. 62—139)

This invention relates to an ice making machine and system and more particularly to a machine and system for automatically and cyclically producing batches of ice pellets.

There is a widespread need and demand in many types of commercial establishments, such as hotels, motels, restaurants, dairies, fish markets and poultry processing plants, for machines capable of producing ice pellets in high volume and with reliability and economy. The ice making machine and system of the present invention are adapted to satisfy these requirements.

The machine provided by the invention is of the type in which a helical rod of ice is formed in the inner tube of a helical tube-in-tube evaporator through which water flows during the freezing portion of the cycle while refrigerant is evaporated in the outer tube, the helical rod of ice being hydraulically ejected from the inner tube during the harvesting portion of the cycle and being broken up into short cylindrical sections or pellets automatically on discharge from the evaporator.

While machines of this general type are known in the prior art, as exemplified, for example, by United States Patent 2,821,070 to Watt et al., all the machines of which we are aware have various deficiencies which it is an object of this invention to overcome and obviate. Thus, for example, one disadvantage of ice pellet machines of the prior art, such as that shown by the Watt et al. patent, is that they are uneconomical in the use of water and waste a considerable quantity of water which is not converted into ice.

Still another disadvantage of the prior art apparatus as exemplified by the machine of the Watt et al. patent is that the system is entirely dependent upon the pressure of the incoming water supply system for the ejection of the ice during the harvesting portion of the cycle and would be incapable of ejecting ice if the pressure of the water supply should drop below a predetermined value.

Another disadvantage of prior art ice making machines is that they frequently employ control systems which depend upon critical settings or adjustments of the control devices, with the result that an improper setting or slight malfunction of any of the control devices may cause faulty and erratic operation of the whole system.

Accordingly, it is an object of this invention to provide a reliable and economical automatic ice making machine of the type which produces ice pellets from a tube-in-tube evaporator.

Another object of the invention is to provide an ice making machine including a control system which does not depend on critical settings or adjustments for proper operation of the system.

Another object of the invention is to provide an ice making machine including a control system in which the same control elements perform the dual function of initiating the harvesting operation and also of preventing continuation of the freezing operation upon malfunction of the machine.

Another object of the invention is to provide an ice making machine which is economical in its use of water and which includes a closed water circulating system in which all of the water flowing through the system is ultimately converted into ice.

A further object of the invention is to provide an

automatic ice making machine of the tube-in-tube evaporator type in which the apparatus is not dependent for ejection of ice pellets during the harvesting portion of the cycle upon the pressure of the incoming water supply system, which is a condition external of the ice making machine and system and thus not subject to control, but which instead includes positive displacement pump means for hydraulically ejecting the ice from the freezing tube during the harvesting portion of the cycle.

A further object of the invention is to provide an ice making machine of the tube-in-tube evaporator type in which the same positive displacement pump means provides one water flow rate during the freezing operation and an increased water flow rate for hydraulic ejection of the ice during the ice harvesting operation.

Still a further object is to provide an ice making machine of the tube-in-tube evaporator type, including a by-pass conduit for the water supply to compensate for the diminished flow of water permitted through the water tube of the evaporator as the ice builds up in the water tube, by permitting water flow through the by-pass tube, and including control means to close the by-pass conduit during the ice harvesting operation.

Still a further object of the invention is to provide an automatic ice making machine including an improved flow control sensing device operating upon the electrolytic conduction principle.

Still a further object of the invention is to provide an ice making machine including a water flow sensing device which is maintained free of accumulations of mush, ice chips and the like which would cause improper operation of the flow sensing device.

Still a further object of the invention is to provide an automatic ice making machine having interlocking and safety controls which insure proper and safe operation of the machine.

Generally speaking, in achievement of these objectives, there is provided in accordance with this invention an ice making machine and system of the tube-in-tube evaporator type including an inner tube through which water to be frozen is circulated, and an outer tube which constitutes the evaporator of a refrigeration circuit and in which refrigerant is evaporated in heat exchange relation with the inner tube to cool the water in the inner tube. Water is continuously circulated through the inner tube by a positive displacement water pump to form a deposit of ice in the inner tube. Control means are provided to sense the rate of water flow through the inner water tube at either the inlet or outlet end of the tube, the rate of flow of the water being inversely proportional to the thickness of the ice coating deposited in the water tube. The water flow sensing control initiates the ice harvesting portion of the cycle when the rate of water flow has decreased to a predetermined value by opening a valve in a hot refrigerant gas by-pass line from the output of the compressor to introduce hot gas into the evaporator tube. The hot gas thaws the ice sufficiently to loosen its adhesion to the tube and to permit the ice to be hydraulically ejected from the tube and be broken into short cylindrical pellets as it emerges from the outlet end of the tube. The water flow sensing control which initiates the ice harvesting operation is supplemented by a water pressure sensitive control which senses resistance to water flow and which maintains the hot gas valve open until the ice is free and moving during the defrosting operation.

An important feature of the system is the provision of means for delivering an increased volume of water to the inlet end of the water freezing tube during the ice harvesting operation to insure positive hydraulic ejection of the ice from the tube. This means for delivering the increased volume of water for ejecting the ice from the

water tube is, in the preferred embodiment of the invention, the same positive displacement pump which circulates the water during the freezing operation, the pump being operated at a higher rate of speed to deliver the increased volume of water. The pump is caused to switch over to its higher rate of speed in response to an increased pressure in the suction line of the compressor when hot gas is being supplied to the evaporator for thawing the ice.

An important feature of the system is the provision of a water by-pass line connected to the inlet water line to the water freezing tube, the by-pass line having a spring-biased valve which progressively opens to by-pass a progressively increasing quantity of water directly to the sump when the increasing deposit of ice in the water freezing tube sufficiently impedes the flow of water through the water freezing tube. The valve in the water by-pass line is so adjusted that it closes the by-pass line during the ice harvesting operation to permit delivery of the entire volume of the water flow from the positive displacement pump to the water tube for hydraulically ejecting the ice.

The by-pass line serves an auxiliary function by providing a water jet which is directed through a sized port or calibrated orifice in the discharge flow sensing means, the water jet maintaining the calibrated orifice free of deposits of mush ice or ice chips which might cause faulty operation of the flow sensing device.

A further feature of the system is the provision of a safety control which shuts down the refrigeration circuit in the event that the water level in the water supply system is too low for proper operation.

Further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view, not to scale, and with various parts shown relatively displaced for clarity, of an ice making machine and system embodying the invention;

FIG. 2 is an elevational view of an ice making machine in accordance with the invention with the proximate end wall of the casing removed;

FIG. 3 is a detail sectional view of the discharge end of the evaporator and of the ice pellet guide;

FIG. 4 is an elevational view of one form of water discharge flow rate sensing means and associated drain pan and sump tank;

FIG. 5 is an elevational view of a modified water discharge flow rate sensing means and associated drain pan and sump tank;

FIG. 6 is an elevational view, partially in section, of an inlet flow control sensing means used at the inlet end of the evaporator;

FIG. 7 is a schematic diagram of the electrical circuit connections of the ice making machine and system;

FIG. 7*a* is a schematic diagram showing a portion of the electrical circuit of FIG. 7 as modified by the use of the discharge flow sensing means of FIG. 4; and

FIG. 8 is a schematic diagram of the electrical circuit connections of the modified water discharge flow rate sensing means shown in FIG. 5.

Referring now to the drawings, and more particularly to FIGS. 1 and 2, the ice making machine and system of the invention are supplied with water from a water supply pipe **10** which is connected to any suitable source of water supply through an appropriate manual cut-off valve (not shown), and which discharges into a reservoir or supply tank **12** through a valve **16** controlled by a float **14** which maintains the water at a constant level in tank **12**. The water in tank **12** is conducted by an outlet conduit **18** to a sump **20** in which the water remains at the same level as that in supply tank **12**.

A suction line **22** conducts the water from sump **20** to the inlet port of a positive displacement water pump **24** driven by a two-speed electric motor **26**. Pump **24** discharges the water through an outlet or discharge pipe **28** to the inlet end of a flow switch generally indicated at **29**, the details of which will be described more fully hereinafter. The discharge end of flow switch **29** is connected to the inner or water tube **30** of a tube-in-tube evaporator unit generally indicated at **32**. The tube-in-tube evaporator unit **32** also includes an outer tube **100** connected in a refrigeration circuit to be hereinafter described. The concentric inner and outer tubes of evaporator unit **32** are wound in a plurality of helical turns of uniform radius of curvature and of constant cross section. At the terminal end of the evaporator unit **32**, the inner or water tube **30** terminates in a short straight end portion **34** which extends substantially tangentially to the curvature of the preceding portion of the helical tubing. The abrupt change in the curvature at the outlet end of inner tube **30** causes the helical rod of ice formed during the freezing process (hereinafter explained) to be broken into short substantially cylindrical lengths or pellets **36** which are discharged from the terminal end portion **34** of water tube **30** through coupling **35** into a guideway **38** located in a drain pan **40** disposed at the outlet end of water tube **30**. Guideway **38** is formed of a plurality of laterally spaced parallel rails through which water may drain to sump **20**.

Positioned immediately laterally adjacent drain pan **40** and in fluid communication therewith through an opening **41** in the lower portion of the wall of drain pan **40** is a vertical drain duct **42** through which any water passing from water tube **30** into drain pan **40** returns to the sump **20**, from which it is again returned by suction line **22** to pump **24** for recirculation.

In order to handle the discharge of pump **24** and to compensate for the diminished flow of water through tube **30** as the ice forms in the tube, a water by-pass line or conduit **68** is tapped into pump discharge line **28** and has an outlet **70** at the end thereof which discharges into sump tank **20**. A spring loaded by-pass valve **72** is interposed in by-pass line **68** and begins to progressively open late in the freezing portion of the cycle to permit passage of progressively increasing amounts of water through by-pass line **68** when the ice formation in water tube **30** begins unduly to restrict the water flow through water tube **30**. For example, by-pass valve **72** may begin to open when the hole through the ice rod or column in tube **30** gets down to approximately ⅜ inch in diameter.

The water flow switch **29** at the inlet end of tube **30** previously referred to is used to measure or sense the flow of water through water tube **30** as a means of detecting when sufficient formation of ice in water tube **30** has occurred for initiation of the ice harvesting portion of the cycle. Water flow switch **29**, by sensing diminution of water flow to the inlet end of water tube **30** also serves as a means of detecting failure of water pump **24** or of pump motor **26**, the failure of either of which would cause a diminution or interruption of water flow to tube **30**. Closure of water flow switch **29**, due to any of the causes just mentioned, is effective to open the hot gas valve **126** to cause defrosting of ice in tube **30**, or to prevent further freezing of water in tube **30** in the event of failure of water pump **24** or of pump motor **26**.

Flow switch **29** is interposed in the water pump discharge pipe **28** posterior the connection of water by-pass line **68**, and immediately adjacent the inlet end of water tube **30**. Flow switch **29**, shown in detail in FIG. 6, may by of the type manufactured under the designation FS–400 by The Gems Company, Inc., of Farmington, Connecticut, and comprises a chamber **76** through which water passes from pump **24** through water line **28** to water tube **30**. Vertically slidable in an apertured partition in chamber **76** is a shuttle **78**, loaded by a spring **80**, and provided with openings **82** through which water flows to the discharge end of the switch. Surmounting the housing enclosing these parts is a switch contact **84** (FIG. 7) actuated by movable shuttle **78**. Contact **84**

is normally closed at no water flow, or below a predetermined minimum water flow, but opens when the shuttle 78 is moved by flow exceeding the predetermined minimum. Closure of switch contact 84 due to a decrease in the water flow to water tube 30 to below the predetermined minimum, or to zero flow, depending upon the adjustment of the switch, causes energization of the circuit of the hot gas solenoid 128, as best seen by reference to the electrical circuit diagram of FIG. 7.

Since flow switch 29 has little or no differential action and would act to reopen the circuit of hot gas solenoid 128 prematurely, a water pressure switch 86 is provided and operates a contact 88 connected in the circuit of hot gas solenoid 128 in parallel with contact 84 operated by flow switch 29, as seen in FIG. 7. Pressure switch 86 is connected by pressure sensing tube 87 to the water discharge line 28 of pump 24. Pressure switch 86 may be set so as to be actuated when the water pressure in pump discharge line 28 increases to a predetermined value, for example, 55–60 p.s.i., normally attained only when two-speed water pump 24 is operating at its higher speed. As will be explained more fully in connection with the description of the refrigeration circuit, two-speed water pump 24 is connected to operate at its higher speed in response to increased pressure in the suction line 102 of the refrigerant compressor 104, due to the passage of hot gas through hot gas line 124, to be described hereinafter. Thus, water pressure switch 86 is normally actuated shortly after the energization of hot gas solenoid 128 by flow switch 29.

Having once closed, water pressure switch 86 has a differential action which causes it to remain closed until the water pressure in pump discharge line 28 drops to a value in the range 15–20 p.s.i., which pressure is attained when the ice in water tube 30 begins to move. When the water pressure in line 28 drops to the range 15–20 p.s.i., water pressure switch 86 opens to deenergize the circuit of hot gas solenoid 128.

While water pressure switch 86 should close when pump 24 operates at high speed, and should open at the time the ice in tube 30 begins to move, the precise pressure settings of switch 86 are not critical, as long as they satisfy the conditions just enumerated. The non-criticality of the adjustment of switch 86 is a distinct advantage in servicing the machine.

As an alternative to the use of the inlet water flow switch 29 hereinbefore described, a discharge water flow sensing means may be used instead, as will now be described.

As best seen in FIG. 4, drain duct 42', which communicates with drain pan 40 in the same manner as drain duct 42 previously described, includes a bottom wall 44 and vertical side walls 46 and 48. A baffle or weir 50 extends vertically upwardly from bottom wall 44 for a portion of the height of drain duct 42, and the vertical side wall 48 of drain duct 42' is deflected in a lateral direction adjacent weir 50 to define a drain passage 52 which is open at its lower end. A chamber 54 is defined in the lower portion of drain duct 42' by side wall 46, weir 50 and bottom wall 44. During the early stages of the ice formation in tube 30 when a considerable quantity of water is being discharged from tube 30, water from chamber 54 overflows weir 50 and passes to sump 20 through passage 52.

The bottom wall 44 of drain duct 42' is also provided with a calibrated outlet port or sized orifice 56 through which water discharges at a controlled or calibrated rate from chamber 54. The controlled rate of discharge through port 56 has particular significance during the later stages of ice formation in tube 30 when the water level in chamber 54 has dropped below the level of the top of weir 50 and calibrated port 56 provides the only means of escape of water from chamber 54. The rate of water flow through port 56 relative to the rate of water discharge from tube 30, and the consequent reduction in level of water in chamber 54 when the discharge from port 56 is greater than the discharge from tube 30, provides a means of sensing the diminution of water flow from the outlet end of tube 30 which, in turn, is an indication of the increasing thickness of ice deposited in tube 30.

As seen in FIG. 4, drain duct 42' incorporates a control device generally indicated at 58 which senses the rate of water discharge from chamber 54, and hence the status of the ice formation in water tube 30, since the water flow at the outlet end of tube 30 diminishes as the ice builds up in tube 30. As the water flow at the outlet end of tube 30 diminishes, there is a corresponding increased water flow through by-pass line 68, to be hereinafter described.

The water discharge flow sensing means generally indicated at 58 includes a buoyant ball or float 60 having a specific gravity less than that of water and positioned in drain duct 42' in vertical alignment with chamber 54. Ball 60 is suspended from the arm 62 of a switch member 64, such as a mercury switch, arm 62 being pivotally movable about the point 66 in accordance with the vertical position of ball 60. When the rate of discharge of water from water tube 30 diminishes sufficiently to cause the level of water in chamber 54 to drop to a predetermined level as determined by the calibration of outlet port 56, consequently causing a drop in the vertical position of ball 60, switch 64 is actuated to energize the hot gas solenoid 128, causing introduction of hot defrosting gas into evaporator tube 100 to initiate the ice harvesting operation, as will be described in more detail hereinafter.

Since the discharge flow sensing means 58 and switch 64 actuated thereby, like flow switch 29 previously described, have little or no differential action and would tend to reopen the circuit of hot gas solenoid 128 prematurely, water pressure switch 86 is used in conjunction with discharge flow sensing means 58 and its switch 64 in the same manner as described in connection with flow switch 29, water pressure switch 86 closing at the water pressure of 55–60 p.s.i. caused by high speed operation of water pump 24, and opening at the reduced pressure of 15–20 p.s.i. which occurs when the ice in water tube 30 begins to move.

When the discharge water flow sensing means 58 just described is used, by-pass conduit 68 is extended through the lower end of drain duct 42' and through the chamber 54 of the drain duct 42' and is provided with a metered or calibrated port 74 which overlies the calibrated outlet port 56 of chamber 54. Thus, when water is passing through by-pass line 68, after by-pass valve 72 has opened, a jet of water is discharged through port 74 of by-pass line 68 and through the calibrated orifice or port 56 of chamber 54. This water jet tends to keep port 56 free of obstructions such as mush ice, or chips of ice which might otherwise clog the port and obstruct the passage of water through it and cause errors in the action of the discharge water flow sensing device 58.

As a safety feature, to prevent operation of the apparatus in the event the liquid level in sump 20 becomes too low, a water safety switch 90 is provided and is operated by float members 94 positioned in an auxiliary tank 92 in fluid communication by means of conduit 96 with sump tank 20. If the level of the water in sump tank 20 and consequently the water level in auxiliary tank 92 drops below a predetermined value, switch 90 is operated to open the electrical circuit of the compressor drive motor 106 to cause shut down of the compressor 104, as best seen in the electrical circuit diagram of FIG. 7.

The refrigeration system includes a compressor 104 driven by a motor 106. Compressor 104 has a suction conduit 102 connected thereto through which the refrigerant gases are admitted for compression. A low side cut-out switch 107 is tapped into refrigerant suction line

102 by tube 109 and serves as a safety device which shuts down the compressor 104 in the event the pressure in suction line 102 should drop to a predetermined abnormally low value indicative of a loss of refrigerant from the system.

A discharge conduit 108 conducts hot compressed gases from compressor 104 to a condenser 110 which cools the compressed gases to liquid form, the condensed refrigerant being conducted by conduit 112 to a refrigerant receiver 114. The refrigerant passes from receiver 114 through outlet conduit 118 in series with expansion valve 116 to the inlet end of outer tube 100 of the tube-in-tube evaporator 32. The opening of expansion valve 116 is controlled by a thermal sensitive element 117 (FIG. 2) in thermal contact with the return or suction line 102 of compressor 104, as is well known in the refrigeration art. After passing through expansion valve 116, the refrigerant passes through conduit 118 and through the outer tube 100 of the tube-in-tube evaporator 32, and returns to the intake side of compressor 104 through refrigerant suction line 102.

In order to permit thawing of the ice in inner tube 30 sufficiently to free the ice from the inner surface of the wall of tube 30 when the ice is to be harvested, a hot gas conduit 124 is tapped into compressor discharge conduit 108 anterior the condenser 110 and connects into refrigerant conduit 118 posterior the expansion valve 116. A "hot gas" valve member 126 controlled by a solenoid 128 is interposed in series with hot gas line 124 and normally closes that line. A check valve 122 is connected in series with hot gas conduit 124 adjacent the connection of conduit 124 to conduit 118, in order to prevent reverse flow of refrigerant through the hot gas line.

To accelerate the defrosting action, hot gas is introduced not only into the inlet end of outer tube 100 through conduit 118, but also through a branch conduit 120 which is tapped into hot gas line 124 posterior valve 126 and anterior check valve 122.

The energization of solenoid 128 to control the opening of hot gas valve 126 is preferably controlled by the flow control switch 29 at the inlet end of water tube 30, but alternatively may be controlled by the discharge flow sensing means 58 and its associated switch 64 at the discharge end of water tube 30. The water pressure switch 86 which senses the pressure in water pump discharge line 28 is used in conjunction with either of the control devices 29 or 58 as previously described.

A pressure actuated switch generally indicated at 130 is also tapped into suction line 102 of compressor 104 by means of sensing tube 132. As will be explained in more detail hereinafter under "Description of Operation," pressure switch 130 connects two-speed water pump motor 26 for high speed operation when pressure switch 130 detects an increase in pressure in suction line 102 after valve 126 has opened to by-pass hot gas through hot gas line 124 during the harvesting portion of the operating cycle.

Description of Electrical Circuitry

The following is a description of the electrical circuitry of the illustrated preferred embodiment of the ice making machine and system.

Referring to the schematic diagram of FIG. 7, electrical power is supplied to the ice making machine from a 220-volt, single-phase A.C. source over power lines 200, 202 and 204, through a main disconnect switch 206. Power line 202 is the neutral line, with a voltage of 110 volts existing between line 202 and each of the power lines 200 and 204.

The circuit of compressor motor 106 is controlled by a relay generally indicated at 208, including a relay operating coil 210 and two normally open contacts 212 and 214 which are operated to closed position when relay operating coil 210 is energized. Relay operating coil 210 is connected across power lines 202 and 204 in series with water safety switch 90 and manually operated switch 216.

The electrical circuit of compressor motor 206 is energized by manually closing switch 216, assuming that main disconnect switch 206 is closed and also assuming that the water level in water safety tank 92 is at a properly safe level to cause water safety switch 90 to be closed. With switches 206 and 90 closed, closure of manual switch 216 energizes relay operating coil 210. Compressor motor 106 is connected to electric power through relay contacts 212 and 214 in series with low pressure cut-out switch 107 which is normally closed and opens only when an abnormally low pressure exists in compressor suction line 102. Thus, with low pressure cut-out switch 107 in normally closed position and with relay coil 210 energized by closure of manual switch 216, relay contacts 212 and 214 are actuated to closed position and compressor motor 106 is connected across power lines 200 and 204 through relay contacts 212, 214 and conductors 216, 218, to energize compressor motor 106.

The two-speed alternating current motor 26 which drives water pump 24 is connected by conductor 220 to neutral power line 202. Pump motor 26 is also connected by conductors 222 and 224 to terminals 226 and 228 of two-way pressure switch 130. Pressure switch 130 includes a single-pole double-throw switch contact 230 which engages one or the other of the terminals 226 or 228 of switch 128, depending upon the pressure existing in refrigerant suction line 102. Movable contact 230 is connected by conductor 232 to power line 204. When movable contact 230 engages terminal 226, the windings of pump motor 26 are connected for low speed operation, and when movable contact 230 engages the terminal 228, the windings of the two-speed water pump motor 26 are connected for high speed operation. Thus, for example, two-speed motor 26 may operate at 1140 r.p.m at its low speed and at 1725 r.p.m. at its high speed.

When compressor 104 is operating on its normal freezing cycle, the pressure in compressor suction line 102 communicated through tube 132 to pressure switch 130 causes contact 230 to be in a position which connects the two-speed motor 26 for low speed operation; whereas, when the harvesting cycle begins and hot defrosting gas is passing through hot gas line 124, the pressure rise in refrigerant suction line 102 communicated through tube 132 to switch 130 causes movable contact 230 of switch 128 to move to a position in which the windings of pump motor 26 are connected for high speed operation to provide an increased volume of water at increased pressure for ejecting the ice from water tube 30.

Hot gas solenoid 128 is connected by conductor 234 to neutral power line 202, the opposite end of solenoid 128 being connected to switch contact 84 of inlet flow switch 29. Contact 84 is connected in parallel with contact 88 of water pressure switch 86. Each of the switches 29 and 86 is a single pole, single throw switch, the closure of either of which will complete the connection of hot gas solenoid 128 to power line 204 through conductor 236, to energize hot gas solenoid 128.

As has been explained previously, contact 84 of inlet flow switch 29 closes in response to a diminished flow of water at the inlet end of tube 30, due to a substantial deposit of ice in tube 30 which requires harvesting, to thereby energize hot gas solenoid 128 and thus initiate the harvesting cycle. However, switch 29 has little or no differential action and would tend to open and de-energize hot gas solenoid 128 prematurely. Therefore, water pressure switch 86 is actuated to close contact 88 by a predetermined increase of pressure in discharge line 28 of water pump 24, switch 86 in the preferred embodiment being set to close contact 88 at a water pressure which is attained only after water pump 24 has switched over to high speed operation. In a modified embodiment, pressure switch 86 may be set to close in response

to increased pressure in water line 28 caused by a predetermined ice build-up in water tube 30.

Description of Operation

The following is a summary of the operation of the ice making machine and system hereinabove described:

To initiate the operation, a manual valve in water inlet line 10 is opened to permit water to pass through water supply pipe 10 to water supply tank or reservoir 12. Water flows from tank 12 through outlet conduit 18 to sump tank 20 and from sump tank 20 through connecting conduit 96 to auxiliary water safety tank 92. The water level in supply tank 12, sump tank 20, and water safety tank 92 finally equalizes at a height which actuates float 14 in water supply tank 12 to close valve 16 to cut off further flow of water into tank 12. As water is drained from tank 12 during the ice making cycle, float 14 controls valve 16 to replenish the water supply. With proper water level in the water supply system, float members 94 in water safety tank 92 close water safety switch 90. As will be seen in the circuit diagram of FIG. 7, water safety switch 90 is in the control circuit of motor 106 which drives compressor 104.

Main power switch 206 (FIG. 7) is then closed to connect single phase 220-volt A.C. electric power to power lines 200, 202 and 204. Upon the closure of main power switch 206, two-speed water pump motor 26 is energized to drive water pump 24 to circulate water to be frozen through water tube 30 of evaporator 32. Water thus begins to circulate through water tube 30 of the evaporator 32 as soon as main power switch 206 is closed. While normally two-speed water pump motor 26 operates at its low speed until after valve 126 in hot gas line 124 opens, at a new start-up of the system the two-speed water pump motor 26 begins operation at its high speed since the temperature-pressure condition in the compressor suction line 102 at starting is such that the two-way pressure switch 130 initially connects the high speed winding of motor 26 across the electric power supply. However, after the system has been in operation a sufficient length of time to reduce the temperature of the circulating water to approximately 33 degrees, the pressure condition in compressor suction line 102 causes two-way pressure switch 130 to connect the low speed winding of the water pump motor 26 to electric power by moving contact 230 into engagement with terminal 226 to connect the low speed winding of the motor to power line 202 in series with conductors 220, 222, contact 230, and conductor 232 to power line 204.

To initiate operation of the compressor 104, manual switch 16 in the circuit of control relay 208 for the compressor motor 106 is then manually closed. Assuming that water safety switch 90 is closed due to the presence of a safe level of water in water safety tank 92, operating coil 210 of relay 208 is then energized to close normally open contacts 212 and 214 in the circuit of compressor motor 106. At this time low pressure cut-out switch 107 in the electrical circuit of compressor motor 106 is closed, since switch 107 opens only in response to an abnormally low pressure condition in compressor suction line 102. With low pressure cut-out switch 107 in closed position, and with relay contacts 212 and 214 closed by the energization of operating coil 210 of relay 208, compressor motor 106 is connected across power lines 200 and 204 by conductors 218 and 216, respectively, to energize compressor motor 106.

As the ice making cycle proceeds, water pump 24 continues to pump water to be frozen into the inlet end of water tube 30 of evaporator 32, the water passing through the entire length of water tube 30 and emerging at the outlet end thereof where it passes into drain pan 40 and thence passes through drain duct 42 to sump tank 20 from which it is returned by conduit 22 to the intake of water pump 24 for recirculation.

In the refrigeration circuit, compressor 104 is driven by compressor motor 106 and draws the refrigerant gas through suction line 102 into the compressor where it is compressed, the hot compressed gas then passing by outlet conduit 108 of the compressor to condenser 110, from whence it passes by conduit 112 to refrigerant receiver 114. The refrigerant then passes through expansion valve 116 in response to regulation by a thermal sensing means 117 positioned in thermal contact with the suction line 102, in accordance with the conventional practice in refrigeration circuits. After passing expansion valve 116, the refrigerant passes through the portion of conduit 118 posterior to expansion valve 116 to the inlet end of outer or refrigerant tube 100 of the tube-in-tube evaporator 32. The refrigerant passing through tube 100 extracts heat from the water in inner water tube 30, cooling the water in tube 30. The spent refrigerant gas then returns to compressor 104 through suction line 102 where it is again compressed.

As ice begins to form on the interior surface of water tube 30, the flow of water through tube 30 gradually diminishes, and when the restriction through tube 30 caused by the ice formation becomes sufficient to cause the water pressure in water pump discharge line 28 to reach a predetermined value, spring-biased valve 72 in water by-pass line 68 begins to progressively open, permitting a progressively increasing flow of water through by-pass conduit 68 directly to sump tank 20, although some water continues to flow through water tube 30 of the evaporator.

As the ice builds up in water tube 30, a point is reached at which the diminished water flow at the inlet end of water tube 30 actuates water flow switch 29 to cause contact 84 of the switch to close to energize the circuit of hot gas solenoid 128. As seen in the circuit diagram of FIG. 7, the circuit of hot gas solenoid 128 is completed from power line 202 through conductor 234, through hot gas solenoid 128, through contact 84 of flow switch 29, and thence by conductor 236 to power line 204.

Alternatively, if the discharge flow sensing means 58 and its associated switch 64 is used in lieu of inlet flow control switch 29 the following sequence of events takes place: As the ice builds up in water tube 30, and water flow at the outlet end of tube 30 is diminished, the water level in chamber 54 of drain duct 42' gradually lowers until it drops below the top level of weir 50, so that calibrated orifice or port 56 in the bottom of chamber 54 becomes the only means of exit of water from chamber 54. As the water level in chamber 54 continues to fall due to the measured flow through calibrated outlet orifice 56, float member 60 gradually drops in chamber 54, until finally a point is reached at which switch 64, which may be a mercury switch, is closed to energize the circuit of hot gas solenoid 128. As seen in the circuit diagram of FIG. 7*a*, the circuit of hot gas solenoid 128 is completed from power line 202, through conductor 234 through the hot gas solenoid 128, through float operated discharge water flow switch contact 64, and thence by conductor 236 back to power line 204.

When valve 126 in hot gas line 124 opens due to the action of either inlet flow switch 29 or discharge flow sensing means 58, depending on which of these devices is used, hot gas passes directly from the discharge conduit 108 of compressor 104 through hot gas line 124, thence through conduit 118 posterior of expansion valve 116 to the inlet end of outer tube 100 of tube-in-tube evaporator 32. Hot gas also passes through by-pass line 120 to an intermediate point of evaporator tube 100. The hot gas passing through the evaporator tube 100 starts to thaw the outer periphery of the ice in water tube 30 so that the ice is soon loosened from its adhesion to the inner surface of water tube 30, preparatory to ejection of ice from the tube. The hot gas after passing through evaporator tube 100 returns through refrigeration suction line 102 to the intake of compressor 104.

The increased pressure in compressor suction line 102 due to the hot gas flow therethrough is communicated by

sensing tube 132 to two-way pressure switch 130 and causes contact 230 of switch 130 to move out of engagement with terminal 226 and into engagement with terminal 228 (FIG. 7) to connect the high speed winding of two-speed water pump motor 26 across the electric power supply. The circuit of pump motor 26 is completed from power line 202 through conductor 220, conductor 224, terminal 228, movable contact 230, and conductor 232 back to power line 204. The two-speed motor 26 operating at its higher speed drives positive displacement water pump 24 at an increased speed which delivers an increased volume of water to the inlet end of water tube 30.

The increased pressure in water discharge line 28 due to the operation of water pump 24 at its higher speed is communicated through sensing tube 87 to water pressure switch 86 to cause the closing of contact 88 of that switch. As will be observed from the circuit diagram of FIG. 7, contact 88 of switch 86 is connected in the circuit of hot gas solenoid 128 in parallel relation with contact 84 of flow switch 29 at the inlet end of tube 30; or, in the alternative arrangement shown in FIG. 7*a*, contact 88 of water pressure switch 86 is connected in parallel with contact 64 of flow discharge sensing means 58. The closing of contact 88 of the water pressure switch in response to the increased water pressure produced by the high speed operation of water pump 24 insures against premature deenergization of hot gas solenoid 128 which might otherwise be caused by opening of either inlet flow switch 29 or alternatively by opening of discharge flow switch 64, neither of which has any substantial differential action.

When the two-speed pump motor 26 switches over to high speed operation as just described, the hot gas from hot gas line 124 has not contacted the ice in tube 30 for a sufficient length of time to thaws the ice to permit movement of the ice. For a brief period after pump 24 begins operating at high speed, the pressure in water discharge line 28 increases substantially, for example, to the order of magnitude of 55–60 p.s.i. At this time, by-pass valve 72 in water by-pass line 68 is open and allows water to flow through by-pass line 68 to sump tank 20. However, when the hot gas from line 124 has defrosted the ice in tube 30 sufficiently to allow the ice to begin to move, the pressure in water pump discharge line 28 drops from a pressure of approximately 55–60 p.s.i. to a pressure of approximately 18 p.s.i. This decrease in pressure in water line 28 causes by-pass valve 72 to close, thereby causing the entire volume of water delivered by pump 24 at its higher speed to impinge against the loosened ice in tube 30, thereby moving the ice and causing it to be ejected from the tube. This application of the entire volume of water delivered by the pump at its high speed operation to cause ejection of the ice is an important feature in the operation of the system and insures satisfactory ejection of the ice from tube 30.

The reduction in pressure in water tube 30 which occurs when the ice has thawed and begins to move not only causes the closing of valve 72 in water by-pass line 68, but also causes the opening of the contact 88 of water pressure switch 86. Contact 88 is in the circuit of hot gas solenoid 128 in parallel with either contact 84 of inlet flow switch 29 (FIG. 7) or contact 64 of discharge flow sensing means 59 (FIG. 7*a*). By the time the ice begins to move either contact 84 or 64, depending on which is used, will have already reopened, so that the opening of contact 88 of water pressure switch 86 opens the circuit of hot gas solenoid 128. The opening of the circuit of solenoid 128 closes valve 126 in hot gas line 124 and stops the flow of hot defrosting gas to the evaporator tube 100. The stopping of the flow of hot gas to evaporator tube 100 after a time lag which may be approximately 20 seconds causes a reduction in pressure in suction conduit 102 of compressor 104 to cause two-way pressure switch 130 to move its contact 230 into engagement with terminal 226, to reconnect water pump motor 26 for low speed operation. The time lag between the opening of water pressure switch contact 88 to deenergize hot gas solenoid 128 and the reconnection of pump motor 26 back to low speed operation is sufficient to permit complete ejection of the ice in water tube 30 with pump 24 operating at its high speed.

The ice moves through tube 30 under the influence of the increased volume of water discharged by pump 24 operating at its high speed and emerges from the terminal portion 34 at the outlet end of tube 30, where the sudden change in curvature of tube 30 causes the heilcal rod of brittle ice, which is actually a thick-walled tube having a very small axial bore, to be broken into short lengths or pellets which pass outwardly onto the guideway 38 in drain pan 40.

After the rod of ice has been completely ejected from water tube 30, the machine is ready for another cycle of operation in which another rod of ice will be formed and harvested. Conditions are restored to those required for the initiation of the freezing cycle, with water passing into the inlet end of water tube 30 by pump 24 operating at its low speed and with compressor 104 sending refrigerant through the normal refrigeration circuit to again cause freezing of the water in tube 30.

Electrolytic Type Discharge Flow Sensing Means and Operation Thereof

There is shown in FIGS. 5 and 8 an electrolytic type water discharge flow sensing means which may be positioned at the discharge end of water tube 30 in lieu of the float operated switch as generally indicated at 58 in FIG. 4. The electrical circuitry of the electrolytic sensing means now to be described may be substituted in place of the discharge flow switch contact 64 in the circuit diagram of FIG. 7, with the switch 274 of the electrolytic sensing device, as will be explained, connected in parallel with contact 88 of water pressure switch 86 to control the energization of hot gas solenoid 128.

All of the structural components shown in connection with the modified device of FIGS. 5 and 8, such as the drain pan 40', the drain duct 42', calibrated discharge port 56', and by-pass conduit 68' are respectively the same as the corresponding parts shown in the FIG. 4 embodiment and designated by the same reference numerals. The embodiment of FIGS. 5 and 8 differs from that of FIG. 4 in that the float operated switch 64 of FIG. 4 has been replaced by two electrodes 250 and 252, respectively, which are positioned in the chamber 54' of drain duct 42'. Electrode 250 terminates at a higher point in chamber 54' than does the electrode 252, and will be referred to as the "high level" electrode 250, while electrode 252 will be referred to as the "low level" electrode.

High level electrode 250 is connected by conductor 254 to terminal 262 of the secondary winding 260 of a step-down transformer 256, the primary winding 258 of which is connected across power lines 202 and 204. The opposite terminal 264 of transformer secondary winding 260 is connected by conductor 266 to one side of relay operating coil 270 of a relay generally indicated at 268, the other end of the relay coil 270 being connected by conductor 272 to the conducting metal surface of the metal drain duct 42'.

Relay 268 includes a normally closed contact 274 which is actuated to open position when relay coil 270 is energized, and a normally open contact 276 which is actuated to closed position when relay coil 270 is energized. Normally closed contact 274 is connected in series with hot gas solenoid 128' across power lines 202 and 204, while normally open contact 276 is connected to low level electrode 252. When normally open contact 276 is closed by energization of relay coil 270, it engages terminal 278 which is connected by conductor 280 to high level electrode 250. Thus, closure of normally open contact 276 upon energization of relay coil 270 is effec-

tive to connect low level electrode 252 to high level electrode 250.

In the operation of the water discharge flow device shown in FIGS. 5 and 8, let it be assumed that the water discharge rate from the outlet end of water tube 30 is such that the water level in chamber 54' immerses both the low and high level electrodes 252 and 250. In this case, the current flow path is completed from terminal 262 of transformer secondary winding 260 through conductor 254 and the liquid path in chamber 54' to the metal ground surface of drain duct 42', thence through conductor 272 to relay coil 270, through relay coil 270 to conductor 266, and thence back to terminal 264 of secondary winding 260. Relay coil 270 is thereby energized and maintains normally closed contact 274 in the circuit of hot gas solenoid 65' open, and closes normally open contact 276 to connect low level electrode 252 to high level electrode 250. Even when the water level in chamber 50' drops out of contact with high level electrode 250, relay coil 270 still remains energized, since the conduction path from terminal 262 of secondary winding 260 is still maintained through low level electrode 252 due to the fact that relay contact 276 is closed. However, when the water level in chamber 50' drops out of contact with the bottom end of low level electrode 252, the current flow through relay coil 270 is interrupted, causing contact 276 to open, and causing normally closed contact 274 to close.

Closure of contact 274 due to the deenergization of relay coil 270 completes the circuit of hot gas solenoid 128', causing hot gas valve 126' to open to permit hot gas from compressor 104 to pass through hot gas line 124 to provide defrosting of the helical tube of ice in water tube 30 as has been previously explained.

After the completion of the ice harvesting operation, the rate of water discharge at the outlet end of tube 30 increases, causing an increase of the water level in chamber 54'. However, the water level in chamber 54' must rise into contact with high level electrode 250 before relay coil 270 is again energized, since contact 276 which connects low level electrode 252 to high level electrode 250 is open during the refilling of chamber 54' and an electrical circuit through the liquid in chamber 54' to transformer secondary winding 260 is not completed until the water level in chamber 54' actually reaches the level of high level electrode 250.

It will thus be seen that the circuit arrangement shown in FIG. 8 requires that after the ejection of the ice from tube 30 has been completed, it is necessary for the water in chamber 54' to rise to the level of high level electrode 250 to open the circuit of hot gas solenoid 128' to terminate the harvesting operation, whereas in order to initiate the harvesting operation by energization of hot gas solenoid 128', it is necessary for the water ot drop to the level of low level electrode 252. This differential action between the condition required for initiation of the ice harvesting operation and for the termination of the ice harvesting operation provides a factor of safety which insures against erratic operation of the electrolytic sensing means.

It is believed to be clear from the foregoing that there is provided in accordance with this invention an ice making machine and system which constitute an improvement in a number of respects over prior art apparatus and systems of this general type. The apparatus of the invention has the advantage that it is economical in its use of water and ultimately converts all of the water flowing through the system into ice without exhausting any of the water into a waste drain as in some of the prior art ice making apparatus and systems.

The ice making apparatus hereinbefore described also has the advantage that it includes a plurality of controls, both of the flow control sensing type and the pressure sensing type, which insure proper operation of the sys- the ice harvesting portion of the cycle. Furthermore, the apparatus of the present invention provides positive means for hydraulically ejecting the ice during the harvesting portion of the cycle which is not dependent upon the pressure of the external water supply system and permits the use of the same water circulating means for circulating water during the freezing operation and for hydraulically ejecting the ice during the harvesting operation.

The system also includes other valuable features, such as the by-pass conduit connected to the water supply for the water freezing tube, which compensates for dimin- tem, and particularly proper initiation and termination of ished flow of water through the water freezing tube when ice forms therein, cooperating with the positive displacement water pump to accommodate water flow from the pump when water flow through the water freezing tube is restricted by the ice deposits.

The control arrangement for the water by-pass conduit, whereby the by-pass conduit is closed for the harvesting portion of the cycle to permit the entire volume of water supplied by the water pump at its high speed operation to be used for ejecting the ice, is also a useful detail of the system. The auxiliary use of the water by-pass line for maintaining the calibrated port of the flow sensing device free of accumulations which would cause improper operation of the sensing device is also a valuable feature.

A further important feature of one form of the system is the electrolytic water flow sensing device which may be used to initiate the ice harvesting operation.

While there have been shown and described certain preferred particular embodiments of the invention which have been found in actual commercial structures to give entirely satisfactory and reliable results, it will be obvious to those skilled in the art that various changes, modifications, additions and subtractions may be made therein without departing from the spirit of the invention as defined by the more broadly worded of the appended claims.

We claim:

1. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube with a rate of flow sufficient to maintain substantially the entire volume of liquid water in said tube in circulation during the ice freezing operation, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, and means responsive to initiation of the thawing operation for increasing the water flow rate to said tube to cause ejection of the ice from said tube.

2. A machine as defined in claim 1 in which said means for sensing when a predetermined deposit of ice has formed includes means for sensing the water flow rate through said water tube.

3. A machine as defined in claim 1 in which said means for sensing when a predetermined deposit of ice has formed includes means for sensing the water flow rate at the discharge end of said water tube.

4. A machine as defined in claim 1 in which said means for sensing when a predetermined deposit of ice has formed includes means for sensing the water flow rate at the inlet end of said water tube.

5. A machine as defined in claim 1 in which said means for sensing when a predetermined deposit of ice has formed includes means responsive to the pressure of water at the inlet end of said tube.

6. An ice making machine comprising a water tube in which ice is formed, an adjustable speed pump means for circulating water through said tube, means for refrigerating the water in said tube to form a deposit of ice in said tube, means causing said pump means to operate at a lower speed while the water is being refrigerated, said pump means having a pumping capacity at said lower speed

sufficient to maintain a rate of flow such that substantially the entire volume of liquid water in said tube is in circulation during the ice freezing operation, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, means responsive to initiation of the thawing operation for increasing the speed of said pump means to increase the water flow from said pump means to said tube so as to cause ejection of the ice from said tube, and control means to maintain said pump means operating at its higher speed until the ice in said tube has been substantially completely ejected.

7. An ice making machine comprising a water tube in which ice is formed, a two-speed positive displacement water pump operable at a high speed and at a low speed, means causing said pump to operate at its low speed to circulate water through said tube during the ice freezing operation at a rate of flow such that substantially the entire volume of liquid water in said tube is in circulation during the ice freezing operation, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, means responsive to initiation of the thawing operation for causing said pump to operate at its high speed to deliver an increased volume of water to said tube so as to cause ejection of the ice from said tube, and control means to maintain said pump operating at its higher speed until the ice in said tube has been substantially completely ejected.

8. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for causing hot gas from said compressor to pass through said evaporator to thaw the ice deposited in said tube sufficiently to permit movement of the ice through said tube, additional sensing means for sensing thermodynamic conditions in the suction line of said compressor, and means responsive to return of the hot gas to the compressor as sensed by said additional sensing means for increasing the water flow rate to said tube to cause ejection of the ice from said tube.

9. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, said pump means having a pumping capacity while the ice is being formed to maintain substantially the entire volume of liquid water in said tube in circulation during the ice freezing operation, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for causing hot gas from said compressor to pass through said evaporator to thaw the deposited ice in said tube sufficiently to permit movement of the ice through the tube, additional sensing means for sensing thermodynamic conditions in the suction line of said compressor, and means responsive to return of the hot gas to the compressor as sensed by said additional sensing means for increasing the water flow rate from said pump means to said tube to cause ejection of the ice from said tube.

10. An ice making machine comprising a water tube in which ice is formed, constant displacement pump means for circulating water through said tube, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for causing hot gas from said compressor to pass through said evaporator to thaw the deposited ice in said tube sufficiently to permit movement of the ice through the tube, and means responsive to return of the hot gas to the compressor for increasing the speed of said pump means and thereby proportionately increasing the water flow from said pump means to said tube to cause ejection of the ice from said tube.

11. An ice making machine comprising a water tube in which ice is formed, a two-speed positive displacement water pump means having a high speed and a low speed, said pump means operating at its low speed to circulate water through said tube during the ice freezing operation, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, control means responsive to deposit of ice in said tube, valve means operable by said control means when the ice is ready for harvesting to cause hot gas from said compressor to pass through said evaporator to thaw the deposited ice in said tube sufficiently to permit movement of the ice through said tube, and means responsive to return of the hot gas to the compressor for causing said pump means to operate at its high speed to deliver an increased volume of water to said tube so as to cause ejection of the ice from said tube.

12. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, a harvesting control means for controlling the harvesting of the ice in said tube, said harvesting control means being responsive to the rate of flow of water through said tube as an indication of the amount of ice deposited in said tube, an electric circuit including valve control means operable by said harvesting control means when the ice is ready for harvesting to cause hot gas from said compressor to pass through said evaporator to thaw the deposited ice in said tube sufficiently to permit movement of the ice through said tube, sensing means for sensing the thermodynamic conditions in the suction line of said compressor, and means responsive to return of the hot gas to the compressor as sensed by said sensing means for increasing the water flow rate from said pump means to said tube to cause ejection of the ice from said tube.

13. An ice making machine comprising a water tube in which ice is formed, an adjustable speed positive displacement pump means for circulating water through said tube, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for by-passing water from the discharge of said pump means as increased deposit of ice in said tube restricts passage of water through said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, means responsive to initiation of the thawing operation for increasing the speed of said pump means to increase the rate of flow of water delivered by said pump means, and means responsive to initial movement of the loosened ice in said tube to close the water by-pass means whereby the entire output flow of said pump means at the increased speed is delivered to said tube to cause ejection of the ice from said tube.

14. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, means for refrigerating the water in

said tube to form a deposit of ice in said tube, a first control means for controlling the harvesting of the ice in said tube, said first control means being responsive to the rate of flow of water through said tube as an indication of the amount of ice deposited in said tube, an electric circuit including means for effecting a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, said first control means being connected in said electrical circuit and being operable to effect said thawing operation, means responsive to initiation of the thawing operation for increasing the water flow rate from said pump means to said tube to cause ejection of the ice from said tube, and a second control means responsive to pressure of water in the discharge line of said pump means and adjusted to be actuated upon increase of the water flow rate from said pump means, said second control means being connected in parallel with said first control means in said electrical circuit to maintain said electrical circuit energized if said first control means becomes deactivated, said second control means having a differential operating characteristic such that said second control means remains activated until the water pressure in the discharge line of said pump means drops to a value substantially corresponding to the water pressure condition when the ice has been ejected from said tube.

15. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, a refrigeration circuit including a compressor and an evaporator, said evaporator being positioned in heat exchange relation with said tube to form a deposit of ice in said tube, a first and second control means for controlling the harvesting of the ice in said tube, said first control means being responsive to the rate of flow of water through said tube as an indication of the amount of ice deposited in said tube and being actuated when the flow of water drops to a predetermined rate, said second control means being responsive to pressure of water in the discharge line of said pump means and being actuated when the pressure of water in the discharge line rises to a predetermined value, an electric circuit including valve control means operable to cause hot gas from said compressor to pass through said evaporator to thaw the deposited ice in said tube sufficiently to permit movement of the ice through said tube, said first and second control means being connected in parallel with each other in said electric circuit to actuate said valve control means to cause thawing of the ice whereby when either said first or second control means is in actuated condition said valve control means is actuated, said second control means having a differential characteristic such that it remains in actuated condition until the pressure of water in the discharge line drops to a value substantially corresponding to the water pressure condition when the ice has been ejected from said tube, and means responsive to return of the hot gas to the compressor for increasing the water flow rate from said pump means to said tube to cause ejection of the ice from said tube.

16. A machine as defined in claim 15 in which said second control means is set to be actuated by the water pressure at the increased water flow rate before the ice has been ejected.

17. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube, means for refrigerating the water in said tube to form a deposit of ice in said tube, a receptacle positioned at the discharge end of said tube for receiving water discharged from said tube, a calibrated discharge port in said receptacle through which water discharges at a predetermined rate, means for directing a jet of water through said discharge port to maintain said port free of obstructions, and control means responsive to the level of water in said receptacle and effective when the level of the water drops to a predetermined height to initiate harvesting of the ice in said tube.

18. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube with a rate of flow sufficient to maintain substantially the entire volume of liquid water in said tube in circulation during the ice freezing operation, said pump means circulating said water in a closed system in which water discharged from said tube is returned to said pump means for recirculation, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, and means for increasing the water flow rate to said tube to cause ejection of the ice from said tube.

19. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube with a rate of flow sufficient to maintain substantially the entire volume of liquid water in said tube in circulation in said tube during the ice freezing operation, said pump means circulating the water in a closed system in which water discharged from said tube is returned to said pump means for recirculation, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for intiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, and means responsive to initiation of the thawing operation for increasing the water flow rate to said tube to cause ejection of the ice from said tube.

20. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through said tube with a rate of flow sufficient to maintain substantially the entire volume of liquid water in said tube in circulation during the ice freezing operation, said pump means circulating the water in a closed system in which water discharged from said tube is returned to said pump means for recirculation, means for refrigerating the water in said tube to form a deposit of ice in said tube, means for sensing when a predetermined deposit of ice has formed in said tube, means actuated by said sensing means for initiating a thawing operation to loosen the deposited ice in said tube sufficiently to permit movement of the ice through said tube, means responsive to initiation of the thawing operation for increasing the water flow rate to said tube to cause ejection of the ice from said tube, and control means responsive to the level of water in said closed system for deactivating the means for refrigerating the water when the water level drops to a predetermined height.

21. An ice making machine comprising a water tube in which ice is formed, pump means for circulating water through a hydraulic circuit which includes said tube, refrigeration means for freezing the water in said tube to form a deposit of ice in said tube, electric switch means connected in said hydraulic circuit in series relation with said tube, said electric switch means being directly responsive to the rate of water flow through said tube and being actuated to a predetermined condition in response to a predetermined diminution of water flow through said tube, control means actuable by a direct electrical connection to discontinue the refrigerating action of said refrigeration means, said control means comprising an electric circuit, said electric switch means being connected in said electric circuit whereby actuation of said switch means to said predetermined condition is effective to discontinue the refrigerating action of said refrigeration means in response either to a predetermined deposit of

ice in said tube or in response to a failure of the water supply to said hydraulic circuit.

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