United States Patent [19]

Matsui et al.

[11] **3,760,600**

[45] **Sept. 25, 1973**

[54] **ICE-MAKING APPARATUS**

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[73] Assignee: **Hitachi, Ltd.,** Tokyo, Japan

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[21] Appl. No.: **217,474**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 92,463, Nov. 24, 1970, abandoned.

[30] **Foreign Application Priority Data**

Nov. 28, 1969 Japan 44/112566

[52] **U.S. Cl.** **62/137,** 62/188, 62/348, 137/392

[51] **Int. Cl.** **F25c 1/12**

[58] **Field of Search** 62/348, 188, 137, 62/135, 352; 137/392

[56] **References Cited**

UNITED STATES PATENTS

3,367,128	2/1968	Hosoda	62/188 X
3,496,380	2/1970	Jones	137/392 X

Primary Examiner—William E. Wayner
Attorney—Paul M. Craig, Jr. et al.

[57] **ABSTRACT**

Improved ice-making apparatus in which water stored in a water pan is cyclically sent onto the surface of an evaporator to make an ice plate while at the same time detecting the water level in the water pan to switch the evaporator to a high-temperature operation, a very small current being made to flow between a plurality of electrodes immersed in the water in said water pan, which current is amplified to energize a detector relay for accurate water-level detection, a switch being provided which puts said evaporator into a cooling operation immediately after detection of a removal of ice.

11 Claims, 4 Drawing Figures

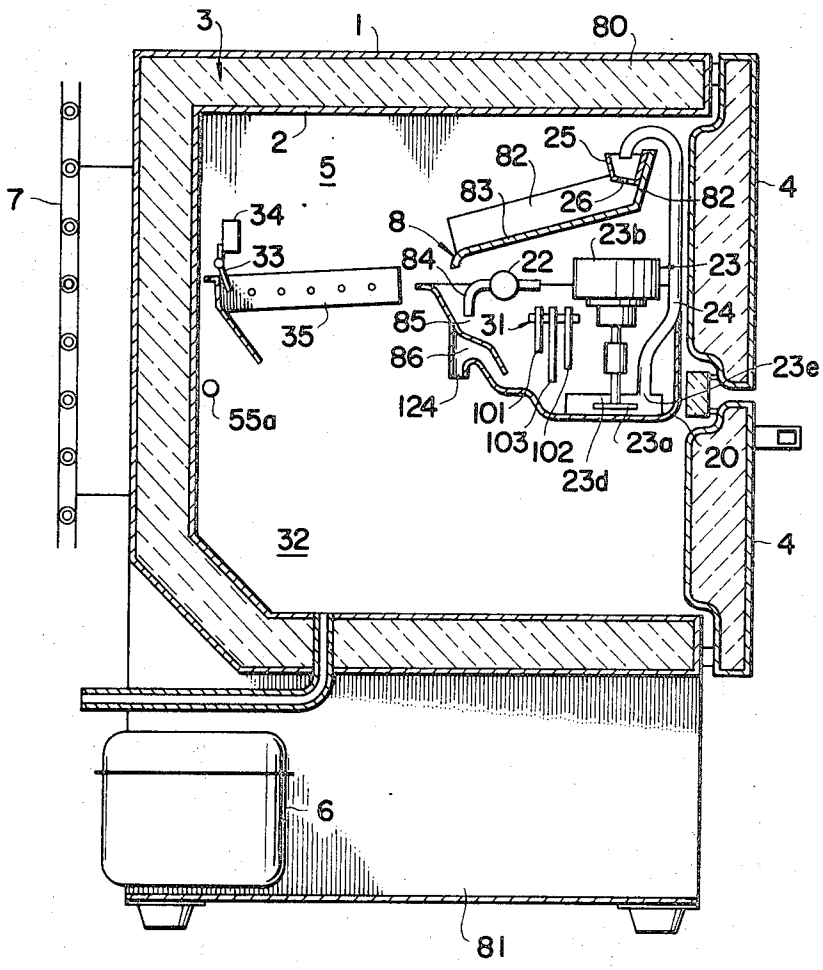


FIG. 1

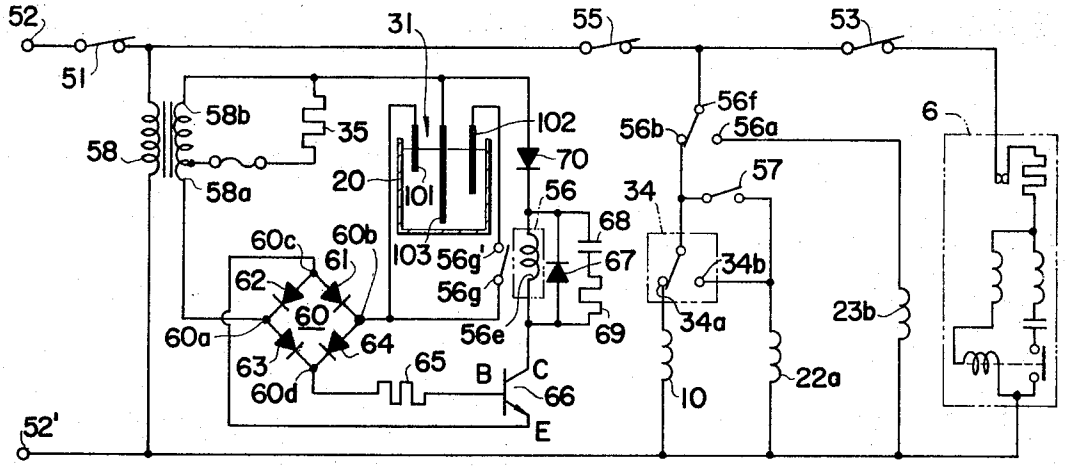

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FIG. 2

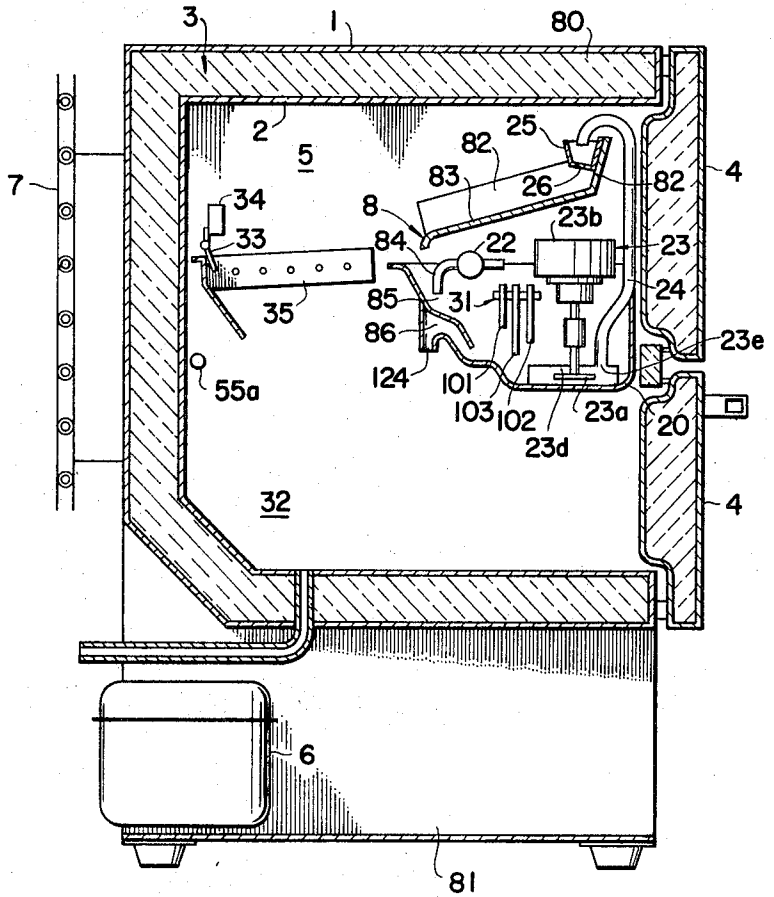

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FIG. 3

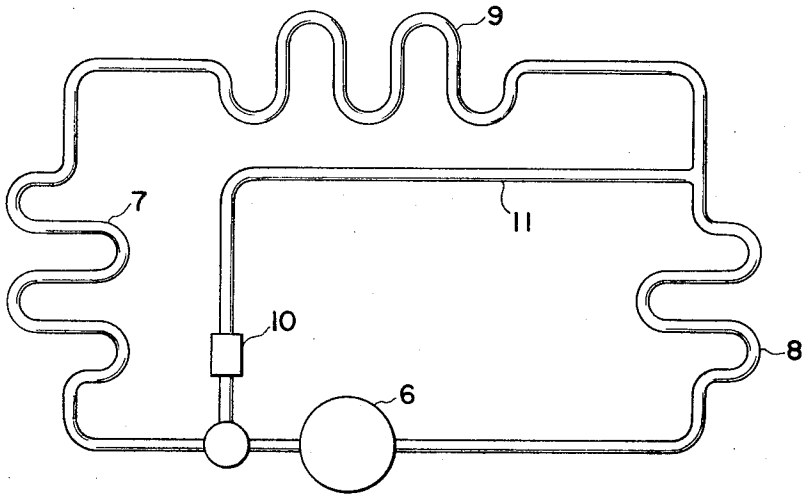
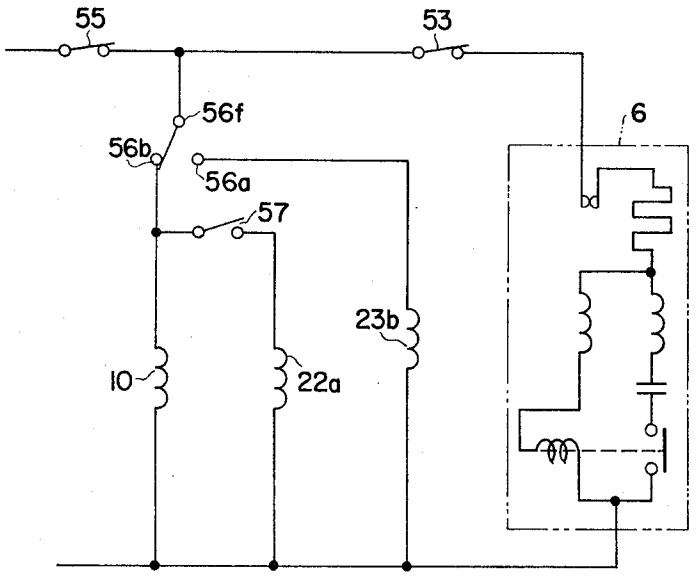


FIG. 4



ICE-MAKING APPARATUS

CROSS-REFERENCES TO RELATED APPLICATION

This application is a continuation-in-part application of our copending application, Ser. No. 92,463 filed on Nov. 24, 1970 now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to ice-making apparatus in which the processes of supplying water, making ice and removing ice are repeated and more in particular to ice-making machinery in which a certain amount of water supplied to a water pan in a heat insulative cabinet is continuously flowed down onto the surface of an evaporator to make an ice plate thereon, which is removed in response to detecting decrease in the water level in the water pan, these processes of supplying water, making ice and removing ice being repeated.

2. Description of the Prior Art

Ice-making apparatus in which water is flowed onto an evaporator generally has a freezing system consisting of a compressor, a condenser and an evaporator which is disposed in a heat insulative cabinet, a water supply system for supplying water to the evaporator consisting of a water supply valve, a water pan and a water pump, means for removing ice by applying a high-tempeature refrigerant to said evaporator, and controlling means for interlocking said freezing system, ice-removing means and water supply system.

It is necessary that the controlling means employed should be able to switch or circulate most efficiently and accurately a series of processes, that is, from a water supply process in which water is supplied from outside to the water pan as soon as the freezing system starts its cooling operation, to an ice-making process in which ice is made by circulating water, and then to an ice-removing process and again to the water supply process.

As a measure to assure the accuracy of the switching from ice making process to ice removing process, some conventional ice-making apparatus employs means for detecting the amount of water in the water pan, and it further employs specifically means for detecting the temperature of the evaporator to make certain a switching from ice-removing to water supply processes.

For example, the ice-making apparatus disclosed in the U. S. Pat. No. 3,367,128 which has been assigned to the assignee of the present application has three electrodes of different lengths in the water pan and a relay which detect, by means of conduction and cut-off states of a current flowing between the electrodes, the upper limit of the water level indicating that a predetermined amount of water is filled in the water pan and the lower limit thereof indicating that a predetermined amount of water has been converted into ice. Water supply is accordingly stopped when the upper limit is detected, while at the same time the evaporator starts into a cooling operation and the water in the water pan is flowed down onto the evaporator by a circulating water pump to make ice. On detection of the lower limit of water level, a high-temperature high-pressure refrigerant is set through the evaporator to remove the ice. The evaporator is provided with a thermostat to detect the condition where the temperature of the evaporator has risen to a predetermined level, whereby water supply is started.

Because of this construction, said patent has a disadvantage that when the electrical conductivity of the water is low, erroneous actuations often result, since said relay is energized directly by the current flowing between the electrodes. By increasing the current to a considerable degree to prevent such errors causes an unwanted electrochemical reaction of the electrodes, thus is made impossible long-time accurate operations of the apparatus.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a highly efficient ice-making apparatus with an improved control circuit.

Another object of the present invention is to provide ice-making apparatus in which each process is accurately actuated.

To achieve these objects, the present invention is based on an idea in which the current flowing between the water level-detecting electrodes in the water pan is minimized but an amplifier, or preferably a transistor amplifier, which can be energized by said minimized current is used to produce a larger output current which is sufficient for energizing a water level-detecting relay.

Further, the apparatus according to the present invention is equipped with a control circuit which particularly employs means for detecting a removal of ice from the evaporator, by means of which the evaporator is switched from an ice-removing operation to a cooling operation and at the same time water supply is started immediately after the detection of the removal of ice.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram showing an embodiment of the present invention.

FIG. 2 is a longitudinal sectional view of the ice-making apparatus according to the embodiment as shown in FIG. 1.

FIG. 3 is a diagram showing a freezing system employed in the embodiment as shown in FIG. 1.

FIG. 4 is a circuit diagram in part showing another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 2, ice-making apparatus embodying the present invention comprises a heat insulative cabinet 3 made up of an outside wall 1, an inside wall 2 and an insulating material 80 filled therebetween, in such a manner as to form an insulated enclosure 5 provided with doors 4 which fit into a front opening of the cabinet 3. A freezing system of the embodiment comprises a compressor 6 disposed in a machine compartment 81, a condenser 7 which is disposed within the compartment 81 or on the back of the cabinet 3, and an evaporator 8 which is provided with a plate-like evaporating surface 83 and overflow-preventing fences 82 provided on both sides and at the rear end of the evaporator and is disposed at the upper part of the enclosure 5 with its forward end tilted downward as shown.

The condenser 7, compressor 6 and evaporator 8 are connected by ducts in such a manner as to form a closed circuit as shown in FIG. 3, and specifically the condenser 7 and evaporator 8 are connected with each other by means of a capillary tube 9. In parallel with the series connection of the capillary tube 9 and condenser 7, the compressor 6 is connected with the evaporator 8 by means of a bypass duct 11 with an electromagnetic valve 10 so that a high-temperature gas may be introduced directly into the evaporator upon open of the valve during the removal of ice.

A water suppy system comprises a water pan 20 which is disposed at a relatively high position in the insulated enclosure 5 with its edge located ahead of the forward end of the evaporator 8, a duct 84 leading from outside water source (not shown) to the water pan 20 and a water supply valve 22 installed in the middle of the duct 84. The water pan 20 is provided with a water outlet 124 in a chamber 86 which separated from a water chamber 85 but connected thereto at the bottom of the water pan 20. The outlet 124 is designed such that its capacity is always held smaller than the amount of water injected through the water supply valve 22.

Inside of the water pan 20, there is a water level detector 31 provided with electrode rods 101, 102 and 103 with their lower ends different in height. The short rod 101 located at the left, has its lower edge slightly hiher than the outlet 124 so as to determine a high limit of the water level where water supply has to be stopped. In other words, water supplied to the water pan 20 through the water supply valve 22 and duct 84 until the water level can reach the lower edge of the short electrode rod 101 due to difference between supply capacity of the valve and the drain capacity of the outlet. Once water reaches the short electrode, then the water supply is stopped and water is drained until the water level is lowered to the height of the outlet 24 where the final water level of the water pan 20 is determined.

The lower edge of the middle electrode rod 102 determines a low limit of the water level in the water pan at the end of ice making. The amount of ice thus produced is equivalent to the difference between the water level at the end of drainage and the height of the lower edge of the middle rod 102. The long electrode rod 103 is located at the center between other electrodes 101 and 102 and constitutes an electrode common to the electrodes 101 and 102. It is obvious that this common electrode 103 suffices so long as its lower edge is lower than that of the middle electrode 102.

A circulating system is provided to pass the water stored in the water pan 20 onto the surface of the evaporator 8 where the water is frozen while water left unfrozen is returned to the water pan to repeat the process, and said circulating system comprises a circulating pump system 23, a duct 24 and a spray 25. The circulating pump system 23 in turn consists of a water pump 23*a* immersed in the water from which ice is to be made and a motor 23*b* disposd at the top of the pump 23*a*, so that said water is sucked in from the inlet 23*d* by the operation of the pump system 23 and introduced from the port 23*e* to the spray 25 through the duct 24. The spray 25 is disposed on the top of the evaporator 8 and has a multiplicity of spraying holes 26 at its bottom, through which water is flowed onto the surface of the evaporator 8. Consequently, the water whose flow is limited by the fences 82 begins to be converted into an ice plate with almost the same area as that of the evaporator 8 while the evaporator 8 is being cooled. Ahead of the tilted evaporator 8 is an electric grid 35 which is also tilted with its forward end downward so as to receive a released ice plate sliding down from the evaporator 8 and to cut the ice plate into small pieces of a predetermined size taking advantage of the gravity by electrically heating. The ice plate thus slided down from the evaporator 8 onto the slanted electric grid 35 causes the lever 33 to rotate, thereby turning the switch 34.

Below the electric grid 35 is an ice compartment 32, and at the upper portion of the ice compartment is provided a heat-sensitive element 55*a* of the thermostat 55 to open the circuit when the amount of ice stored reaches a predetermined level.

Incidentally, instead of the thermostat as used in this embodiment, it is possible to employ a weight switch which detects a condition at which the total amount of ice formed exceeds a predetermined value.

Now explanation will be made of a control means for controllng the apparatus according to the present invention with reference to the circuit diagram of FIG. 1. A power switch 51 connected nearer to power source terminals 52, 52′ than any other components and performs openings and closings of all component circuits which will be described below. The compressor 6 is connected to the power supply source (not shown) through the contacts of a safety thermostat 53 for preventing over-heating which is located on the back of the evaporator 8 and a bin thermostat 55 for controlling the amount of ice to be stored.

The safety thermostat 53 which is usually closed will be opened under abnormal conditions, for example, a failure of water supply which causes a high-temperature gas to overheat the evaporator 8.

The circulating pump motor 23*b* is inserted between a contact 56*a* of a relay 56 which will be described later and another power source terminal 52′.

The relay 56 has an electromagnetic coil 56*e*, a movable contact 56*f* which is opposed to two contacts 56*a* and 56*b*, and a movable contact 56*g* which is opposed to one contact 56*g*′. As long as a specified amount of electric current is flowing in the coil 56*e*, the contact 56*f* is closed on the side of contact 56*a* which is connected with said pump motor 23*b* whereas the contact 56*g* is maintained connected with the contact 56*g*′. When there is no current flowing in the coil 56*e*, the contact 56*g* is disconnected with the contact 56*g*′ while the contact 56*f* is connected with the contact 56*b*, thus opening the contact 56*a*.

The contact 56*b* is connected with a movable contact 34*c* of the switch 34 and the thermostat 57 of the evaporator 8. The contact 34c of the switch 34 is usually connected with the contact 34*a* when it is not rotated under absence of ice on the heater 35, whereas it is switched to the contact 34*b* when roated by the arrival of ice.

The contact 34*a* is connected with the solenoid valve coil 10 which operatively permits a high-temperature refrigerant gas to be directly sent to the evaporator 8 through the duct 11, the solenoid valve coil 10 being connected with the power source terminal 52′. The thermostat 57 which is placed on the back of the evaporator 8 is closed when the temperature of the surface of the evaporator 8 exceeds 60° F (at which there never

exists ice on the evaporator), and is opened when the temperature thereof goes below 30° F.

The thermostat **57** is connected in series with one end of a water solenoid valve coil **22***a*, and the other end of said coil is connected with the power source terminal **52'**. The contact **34***b* is connected with a junction point between the thermostat **57** and the one end of the water solenoid valve coil **22***a*, so that the water solenoid valve coil **22***a* is connected with the contact **56***b* through the thermostat **57** and/or the contacts **34***b* and **34**of the switch **34**.

The water level-detecting means according to the present invention is provided on the secondary side of the transformer **58**. It is desirable that the primary side of the transformer **58** be connected directly with a power supply through the switch **51**. Though the electric grid **35** is connected with the secondary side of the transformer **58**, it may be alternatively connected directly with a power supply.

Rectifying diodes **61**, **62**, **63** and **64** form a full-wave rectificaiion bridge **60** and a junction point **60**a of the bridge **60** is connected with a termianl **58***a* in the secondary of the transformer **58**. Another junction point **60***b* of the bridge is connected with the short electrode rod **101** of the water level detector **31** and also with the middle electrode rod **102** through the contacts **56***g* and **56***g'* of the relay **56**. Still another junction point **60***c* of the bridge is connected with the emitter E of a transistor **66**, and the remaining junction point **60***d* with the base B of said transistor through a resistor **65**. The long electrode or common electrode **103** of the water level detector **31** is connected with the other terminal **58***b* of the secondary of the transformer **58**. The collector C of the transistor **66** is connected with the terminal **58***b* of the secondary of said transformer **58** through a parallel circuit consisting of the coil **56***e* of the relay **56**, protective diode **67** for the transistor **66** and a series circuit which in turn consists of a smoothing capacitor **68** and a smoothing resistor **69**, and also through a diode **70** for protecting the electrodes.

The fixed resistor **65** is inserted between the rectifying bridge **60** and the base B of the transistor **66** in order that the current in the collector C of the transistor **66** is set at such a value that a minimum current sufficient for energizing the relay **56** is secured and that the current flowing in the water level detector **31** is minimized.

When a current over the predetermined minimum value flows in the coil **56***e* of the relay **56**, the contact **56***f* turns to the side of the contact **56***a* away from the contact **56***b* while at the same time the contact **56***g* gets connected with the contact **56***g'*, with the result that a current continues to flow in the base B of transistor **66** through the electrode **102**.

Operations of the ice-making apparatus as constructed above will now be explained. First, upon closure of the power switch **51**, since the thermostat **55** is closed due to no ice stored at an initial state, the compressor starts operation. There is, of course, no water in the pan under this initial condition, and therefore the contact **56***f* of the relay **56** is connected with the contact **56***b*, thereby the pump motor **23***b* is not operated. The switch **34** for detecting an ice plate is closed on the side of the contact **34***a*, which energizes the solenoid valve coil **10**, since there is no ice plate on the electric grid **31**. As a result, the ice-making apparatus is in a "hot gas operation" with a high-temperature gas directly sent from the compressor **6** to the evaporator **8**.

The thermostat **57** is thus closed when the temperature becomes 60° F of higher and therefore the water solenoid valve coil **22***a* is energized, so that its duct is opned to lead water through the duct toward the water pan **20**.

If the temperature around the thermostat **57** is low enough even in the initial state, an opened thermostat **57** does not cause a water supply for the time being, thus the apparatus is retained in a hot-gas operation, until the temperature of the evaporator **8** exceeds 60° F, then, water begins to be supplied.

When the water level in the water pan rises so high as to reach the short electrode rod **101** of the water level detector **31**, a very small current begins to flow between the electrode **101** and the already immersed longest electrode rod **103**, so that an amplified current large enough to energize the relay coil **56**e flows in said relay coil **56***e* which is connected with the collector C of the amplifying transistor **66**.

As a consequence, the contact **56***g* of the relay **56** is connected with the contact **56***g'* and the contact **56***f* turns to the contact **56***a*, so that the pump motor **23***b* is started and the water in the water pan is sent onto the evaporator **8**, while at the same time closing the water solenoid valve coil **22** and solenoid valve coil **10**, whereby the freezing system starts the cooling operation.

The water in the water pan **20** is continuously drained, while being stirred by the pump system **23**, through the bottom of the water pan out of the outlet **124** until the water level in the water pan lowers to the height of the outlet **124**. Because of this stirring, sediments deposited in the water pan, if any, will be reduced in concentration, to thereby obtain protecting and lengthening of the life of the electrodes. As a result of the drainage, the water level of the water pan **20** does down quickly away from the short electrode **101** of the water level detector **31**. But since the short electrode **101** is short-circuited the middle electrode **102** by the relay contact **56***g* — **56***g'* due to closure of the relay **56**, a very small current defined by the fixed resistor **65** still flows between the long electrode **103** and the middle electrode **102** to thereby keep the relay **56** excited. Therefore, water continues to be sent to the evaporator **8** by the pump system **23** and the compressor **6** continues a cooling operation, so that an ice plate is gradually formed on the evaporator **8**, lowering the water level of the water pan **20**.

When the ice-making operation causes the water level in the pan **20** below the lower edge of the electrode **102**, a current stops flowing in the water level detector **31**, whereby the relay coil **56***e* is de-energized and the contacts **56***g* and **56***g'* are disconnected to cause the contact **56***f* to turn to the contact **56***b*. At this time, since the evaporator **8** is below 30° F in temperature as a matter of course with the thermostat **57** opened, and since there is no ice on the electric grid **35**, the contact **34***c* of the switch **34** is connected with the contact **34***a*. As a result, a closed circuit is formed which is namely from the power supply, contact **56***b*, contact **34***a*, solenoid valve coil **10** to the power supply with the result that the solenoid valve coil **10** is opened, putting the freezing system into a hot gas operation to heat the evaporator **8**. Then the ice plate begins to melt gradually from the outer surface **81** of the evaporator **8** sliding down the slope of the evaporator and finally

drops onto the electric grid **35.** Under this condition, the temperature of the thermostat **57** is not high enough to close its contacts and the thermostat **57** is still opened, but the lever **33** is rotated by the released ice plate and the switch **34** is closed on the side of contact **34***b* away from the contact **34***a*. Consequently, the freezing system returns to a cooling operation and at the same time a closed circuit is formed from the power supply, contact **56***b*, contact **34***b*, water solenoid valve coil **22***a* to the power supply, thereby starting again to supply water.

Meanwhile, the ice plate which dropped onto the electric grid **35** is cut thereby and further fallen down into the ice compartment **32,** thereby turning the contact **34***c* of the switch **34** to the side of the contact **34***a*. However, since the relay **56** has already been actuated to close the contact **56***f* on the side of the contact **56***b*, the cooling operation has also been started, before the turning of the switch **34** by constructing the water supply system in such a manner that the water supply to the water pan **20** can be completed before the ice drops from the heater **35.** Since, as described above, a water supply as well as a cooling operation begins by means of the switch **34** as soon as the removal of ice is completed or an ice plate drops on the electric grid **35,** the evaporator **8** returns to a cooling operation before being heated to a point where the thermostat **57** is energized. As a consequence, the ice-making efficiency of the evaporator is much improved as compared with the conventional machinery.

It is needless to say that, at the start of machine operation when the switch **34** is not actuated, the thermostat **57** causes the machinery to begin a freezing process as described above.

When the ice compartment becomes in full with lumps of ice of a predetermined amount, the thermostat **55** opens thereby to de-energize the compressor **6,** pump **23,** water solenoid valve coil **22** and solenoid valve coil **10.** Under this condition, however, the transformer **58** is energized and therefore the relay **56***e* keeps the thermostat **55** ready to be closed. Then, when, due to the lapse of time of consumption of ice, the amount of ice in the ice compartment **32** is reduced to such a degree as to raise the temperature of the heat-sensitive element **55***a* of the thermostat **55** to a predetermined level, the thermostat **55** is closed again thereby to start the compressor **6** and pump system **23.**

The pump system **23** will not start, if the condition of the thermostat **55** before being opened corresponds to a condition in which the pump system **23** is stopped. If the thermostat **57** is closed, water begins to be immediately supplied, whereas if the thermostat is opened, the solenoid valve coil **10** is energized to put the apparatus into a hot-gas operation with the result that water supply begins with the increase in temperature of the evaporator **8.**

Assuming that water supply to the ice-making apparatus has failed, no water will be supplied in spite of instructions by the switch **34** or thermostat **57** to supply water. If this condition continues, the freezing system is kept in a hot-gas operation, causing the evaporator **8** to rise abnormally into a high temperature. When the temperature of the evaporator **8** exceeds 122° F under such abnormal conditions, the safety thermostat **53** is opened and thereby only the compressor **6** is stopped. Then the temperature of the evaporator **8** decreases, and when it falls below 92° F, the compressor **6** is again started. This intermittent operation of the compressor **6** prevents the lumps of ice in the ice compartment **32** from being abnormally melted. Meanwhile, the relay **56** and thermostat **57** continue to give instructions on water supply all this while and hence water supply begins for continued ice making as soon as water pressure is applied to the water supply valve **22,** regardless of whether or not the compressor **6** is in operation.

During this cycle which is repeated to store more and more lumps of ice in the ice compartment **32,** the current flowing in the water level detector **31** is divided by the transistor **66** into an output circuit thereof and a water level detector circuit including the resistor **65.** Therefore, by selecting the resistor **65** in such a manner that the water level detector **31** is actuated with the water of minimum electric conductivity, the current is held minimum evn in the water of a high electric conductivity, which combines with the drainage system to improve the reliability of the electrodes, while at the same time supplying to the relay coil **56***e* a sufficient current for energization thereof thereby to secure accurate operations.

Although the switch **34** for detecting an ice plate is employed in the above embodiment, it is possible to eliminate switch **34.**

Another embodiment of the present invention, in which the switch **34** is not employed, is explained according to FIG. **4.** In FIG. **4,** the same portions as shown in FIG. **1** are designated with the same numerals respectively, and only the main portion of the circuit shown in FIG. **1** is illustrated. It is no more than that the contacts **34***a* and **34***c* in the circuit in FIG. **1** are connected constantly in this embodiment.

According to this constitution, even after an ice plate formed on the outer surface of the evaporator separates from the evaporator and drops onto the heater, a hot gas continues to be sent to the evaporator so as to cause the temperature of the evaporator to rise until the thermostat **57** is closed at a predetermined temperature high enough to close its contacts thereby opening the water solenoid valve so that the machinery begins a freezing process when the water supply is completed.

According to this constitution, there is a disadvantage in that the time during which the high-temperature refrigerant gas for removing an ice plate from the evaporator continues to be sent to the evaporator is longer than that of the aforesaid embodiment, on the other hand, there is however an advantage in that the switch **34** is eliminated thereby simplifying the constitution of the electric circuit of the apparatus and decrease the cost of the product.

We claim:

1. An ice-making apparatus comprising:

a loop freezing circuit formed by a compressor, a condenser, a capillary tube, and an evaporator connected together into a loop therewith;

a bypass conduit for bypassing said condenser and said capillary tube so as to connect an output of said compressor to an input of said evaporator;

a refrigerant valve adapted to be opened and closed for allowing a refrigerant to pass through said bypass conduit from said compressor to said evaporator when it is opened;

a water pan for storing water therein;

a water supply valve adapted to be opened and closed for allowing water to pass therethrough into said water pan when it is opened;

a water pump for supplying water in said water pan onto said evaporator so as to let water fall down along outer periphery of said evaporator;

a water guide member for guiding water flown down from said evaporator back to said water pan; and

a heater for cutting an ice plate formed on and released from said evaporator into lumps of ice so as to cause said lumps to fall down;

wherein a control device for controlling the operation of said ice-making apparatus comprises;

a. a water level detector for generating first and second signals,

said first signal being generated when a water level in said water pan reaches above a predetermined high level and being maintained until the water level reaches below a predetermined low level,

said second signal being generated when the water level reaches below the predetermined low level and being maintained until the water level reaches above the predetermined high level;

b. first switch means adapted to be actauted to cause said pump to be actauted so long as the first signal is maintained;

c. second switch meand adapted to be actuated to open said refrigerant valve so long as the second signal is maintained;

d. a thermostat provided on said evaporator, said thermostat being adapted to be actuated when the temperature of said evaporator reaches above a predetermined high temperature at which no ice can adhere to said evaporator and adapted to be relieved from the actuation thereof when the temperature of said evaporator reaches below a predetermined low temperature at which ice can be formed;

said water supply valve being opened while said second switch means and said thermostat are actuated simultaneously,

e. a first ice-detection switch adapted to be actuated so long as an ice plate formed on and released from said evaporator is present on said heater, said first ice-detection switch being connected in parallel to said thermostat, so that said water supply valve is opened while said second switch means and at least one of said thermostat and said first ice-detection switch are actuated simultaneously, and

f. a second ice-detection switch adapted to be actuated so long as no ice exists on said heater, said second ice-detection switch being connected in series with said second switch means, so that said refrigerant valve is opened while said second switch means and said second ice-detection switch are actuated simultaneously.

2. The control device for an ice-making apparatus according to claim **1**, wherein said water level detector comprises:

first and second electrodes provided in said water pan at the predetermined high and low levels, respectively, said first electrode being adapted to contact with the water only when the water level reaches above the predetermined high level, said second electrode being adapted to contact with the water while the water level reaches above the low level;

a common electrode provided at a predetermined position below the predetermined low level in said water pan;

an electric power source having two terminals, one of said terminals being connected to said common electrode and the other one of said terminals being connected to said first and second electrodes to thereby cause a current from said power source to flow between said common electrode and at least one of said first and second electrodes;

an amplifier adapted to amplify the current so as to produce an amplified out-put current; and

a relay having a contact adapted to be closed when said relay is energized by the output current of said amplifier, said contact being connected in series with said second electrode and said power source so that said relay is maintained in its energized state until the water level reaches below the predetermined low level once said relay is energized,

said first switch means being adapted to be actuated so long as said relay is energized,

said second switch means being adapted to be actuated so long as said relay is not energized.

3. The control device for an ice-making apparatus according to claim **2**, wherein said refrigerant valve has a first solenoid coil adapted to be energized through said second switch means, and said water supply valve has a second solenoid coil adapted to be energized through being in series with said second switch means and said thermostat.

4. An ice-making apparatus comprising:

a freezing system including a compressor; a condenser connected to said compressor; a capillary tube connected to said condenser; an evaporator connected between said capillary tube and said compressor, said condenser, said capillary tube and said evaporator forming a closed freezing circuit; a bypass conduit for introducing a refrigerant gas from said compressor to said evaporator; and a refrigerant valve disposed in said bypass conduit adapted to be opened and closed in response to actuation and non-actuation of a solenoid coil therefor, respectively;

a water system including a water pan, a water supply valve adapted to be opened and closed in response to actuation and non-actuation of a solenoid coil therefor respectively so that water is supplied to said water pan through said water supply valve while it is opened, a pump for supplying water in said water pan onto said evaporator, and a guide member for guiding water thus supplied onto said evaporator back into said water pan; and

a heater for receivng an ice plate formed on and released from said evaporator and for cutting said ice plate into lumps thereof so as to let them fall down,

wherein a control device for said ice-making apparatus comprises:

a. a water level detector including first and second electrodes provided in said water pan at predetermined high and low positions which set the water level in said water pan at predetermined high and low limits, respectively, a common electrode provided in said water pan at a predetermined position below the predetermined low limit, an electric power source having two terminals connected to said common electrode at one terminal thereof and to said first and second elec-

trodes at the other terminal thereof so as to cause a current to flow between said common electrode and at least one of said first and second electrodes, an amplifier for amplifying the current so as to produce 1n amplified output current, and a relay adapted to be excited by the amplified output current, said relay having first, second and third relay switches, both said first and second relay switches being adapted to be closed while said relay is excited, said third relay switch being adapted to be opened while said relay is excited, said first relay switch being connected in series to said power source and said second electrode;

b. a thermostat provided on said evaporator said thermostat being adapted to be closed when the temperature of said evaporator exceeds a predetermined value at which no ice can adhere to said evaporator and adapted to be opened when the temperature of said evaporator reaches below a predetermined low value at which ice can be formed;

c. means for supplying electric power to said solenoid coil for said water supply valve through said third relay switch and said thermostat so as to cause said water supply valve to be opened while said third relay switch and said thermostat are closed concurrently;

d. means for supplying electric power to said solenoid coil for said refrigerant valve through said third relay switch so as to cause said refrigerant valve to be opened while said second relay switch is closed;

e. means for supplying electric power to said pump through said seocnd relay switch so as to cause said pump to be actautd while said second relay switch is closed,

f. a first ice-detection switch adapted to be actuated so long as an ice plate formed on and released from said evaporator is present on said heater, said first ice-detection switch being connected in parallel to said thermostat, so that said water supply valve is opened while said second switch means and at least one of said thermostat and said first ice-detection switch are actuated simultaneously, and

g. a second ice-detection switch adapted to be actuated so long as no ice exists on said heater, said second ice-detection switch being connected in series with said second switch means, so that said refrigerant valve is opened while said second switch means and said second ice-detection switch are actuated simultaneously.

5. An ice-making apparatus comprising:

a freezing system having a closed circuit including a compressor for compressing a refrigerant, a condenser, a capillary tube and an evaporator, a bypass conduit for introducing a refrigerant gas from said compressor to said evaporator, and a refrigerant valve disposed in said bypass conduit;

a water system having a water pan, a water supply valve for supplying water therethrough to said water pan, a pump for supplying water onto said evaporator and a guide member for guiding water back from said evaporator to said water pan;

a heater for receiving an ice plate formed on and released from said evaporator and for cutting said ice plate into lumps thereof to thereby let them fall down; and

a control device for said ice-making apparatus comprising:

a. a water level detector including two electrodes disposed in said water pan for setting the water level in said water pan at predetermined high and low limits respectively, a common electrode disposed in said water pan which can be conducted via water to said two electrodes, and an electric power supply source connected at one terminal thereof to said common electrode and at the other terminal thereof to said two electrodes,

b. an amplifier adapted to amplify a current flowing between said common electrode and at least one of said two electrodes,

c. a relay adapted to be excited by an output current of said amplifier,

d. a first relay switch adapted to be closed in response to excitation of said relay, said first relay switch is connected in series to said power supply source and one of said two electrodes for setting the low limit of said water level,

e. a second relay switch adapted to be closed in response to the excitation of said relay for actuating said pump while it is closed,

f. a third relay switch adapted to be opened in response to the excitation of said relay,

g. a thermostat installed on said evaporator, said thermostat adapted to be closed when the temperature of said evaporator exceeds a predetermined level for preventing said evaporator from over-heating,

h. a water solenoid valve coil adapted to be energized through said third relay switch and said thermostat to thereby open said water supply valve,

i. a solenoid valve coil for said refrigerant valve adapted to be energized through said third relay switch to thereby open said refrigerant valve,

j. a first ice-detection switch adapted to be actuated so long as an ice plate formed on and released from said evaporator is present on said heater, said first ice-detection switch being connected in parallel to said thermostat, so that said water supply valve is opened while said second switch means and at least one of said thermostat and said first ice-detection switch are actuated simultaneously, and

k. a second ice-detection switch adapted to be actuated so long as no ice exists on said heater, said second ice-detection switch being connected in series with said second switch means, so that said refrigerant valve is opened while said second switch means and said second ice-detection switch are actuated simultaneously.

6. An ice-making apparatus comprising:

a freezing system having a closed circuit including a compressor for compressing a refrigerant, condenser, a capillary tube and an evaporator, a bypass conduit for introducing a refrigerant gas from said compressor to said evaporator, and a refrigerant valve disposed in said bypass conduit;

a water system having a water pan, a water supply valve for supplying water therethrough to said water pan, a pump for supplying water onto said

evaporator and a guide member for guiding water back from said evaporator to said water pan;

a heater for receiving an ice plate formed on and released from said evaporator and for cutting said ice plate into lumps thereof to thereby let them fall down; and

a control device for said ice-making apparatus comprising:

a. a water level detector including two electrodes disposed in said water pan for setting the water level in said water pan at predetermined high and low limits respectively, a common electrode disposed in said water pan which can be conducted via water to said two electrodes, and an electric power supply source connected at one terminal thereof to said common electrode and at the other terminal thereof to said two electrodes,

b. an amplifier adapted to amplify a current flowing between said common electrode and at least one of said two electrodes,

c. a relay adapted to be excited by an output current of said amplifier,

d. a first relay switch adapted to be closed in response to excitation of said relay, said first relay switch is connected in series to said power supply source and one of said two electrodes for setting the low limit of said water level,

e. a second relay switch adapted to be closed in response to the excitation of said relay for actuating said pump while it is closed,

f. a third relay switch adapted to be opened in response to the excitation of said relay,

g. a thermostat installed on said evaporator, said thermostat adapted to be closed when the temperature of said evaporator exceeds a predetermined level for preventing said evaporator from over-heating,

h. a water solenoid valve coil adapted to be energized through said third relay switch and said thermostat to thereby open said water supply valve,

i. a solenoid valve coil for said refrigerant valve adapted to be energized through said third relay switch to thereby open said refrigerant valve,

j. a detecting switch for detecting removal of an ice plate from said evaporator, said detecting switch having a first contact switch adapted to be closed and a second contact switch adapted to be opened so long as an ice plate exists on said heater, respectively, and

k. means for connecting said first contact switch in parallel with said thermostat,

said second contact switch being connected in series to said third relay switch and said solenoid valve coil for said refrigerant valve.

7. An ice-making apparatus according to claim **6**, in which said amplifier in said contol device includes a transistor whose base current is controlled by a current flowing between said common electrode and at least one of said two electrodes, said relay being constructed in such a manner as to be energized by a collector current of said transistor, thereby minimizing the current flowing between the electrodes while making a large current flow in said relay to ensure accurate operations.

8. An ice-making apparatus according to claim **1**, in which said control device is also equipped with a switch which is opened by detecting a maximum amount of ice produced, whereby said compressor, said water solenoid valve coil, said solenoid valve coil and said circulating pump are de-energized, a cooling operation being started immediately after a removal of ice.

9. A control device for an ice-making apparatus having: a water pan; water supply means for operatively supplying water into said pan; an evaporator; a water pump for operatively supplying water in said pan onto said evaporator to flow down along an outer wall of said evaporator; a guide member for guiding water back from said evaporator to said pan; refrigerant means for supplying to said evaporator a refrigerant in one of a compressed gaseous state and in a condensed liquid state so as to operate said evaporator in an ice-removing condition and in a cooling condition, respectively, and a heater for receiving an ice plate formed on and then released from said evaporator and for cutting the ice plate into lumps of ice so as to cause said lumps to fall down;

said control device comprising:

a. a water level detector for generating a detection signal when a water level in said pan exceeds a predetermined high level, said detection signal being maintained until the water level falls below a predetermined low level;

b. first switch means actuated while said detection signal lasts for operatively actuating said pump;

c. a thermostat provided on said evaporator and actuated when the temperature of said evaporator exceeds a predetermined high temperature at which ice can be removed from said evaporator, the actuation of said thermostat being maintained until the temperature of said thermostat falls below a predetermined low temperature at which ice can be formed;

d. second switch means actuated while said detection signal is not generated;

e. a first ice detection switch actuated while said heater receives an ice plate thereon; and

f. a second ice detection switch actuated while no ice plate exists on said heater;

said refrigerant means being controlled to operatively supply to said evaporator the refrigerant in the compressed gaseous state only while said second switch and said first ice detection switch are concurrently actuated, and otherwise supplying the refrigerant in the condensed liquid state, said water supply means being actuated to supply water into said water pan only while said second switch means and at least one of said thermostat and second ice detection switch are concurrently actuated.

10. The control device according to claim **9**, wherein said water level detector comprises:

first and second electrodes provided in said water pan at the predetermined high and low levels, respectively;

a common electrode provided in the water in said water pan so that said common electrode is connected through the water to said first and second electrodes when the water level in said water pan reaches said predetermined high and low levels, respectively;

an electric power source with two terminals one of which is connected to said common electrode and the other of which is connected to said first and second electrodes, respectively;

an amplifier for amplifying an electric current flowing between said common electrode and at least one of said first and second electrodes through the water in said water pan; and

a relay responsive to said amplifier and which is rendered one of on and off in response to one of an on and off condition of the electric current through the water, respectively;

said relay having a first contact switch which is closed when said relay is rendered on and connected between said second electrode and said other terminal of said power source, a second contact switch which is closed when said relay is rendered on and acts as said first switch means, and a third contact switch which is closed when said relay 1s rendered off and acts as said second switch means.

11. In an ice-making apparatus having: a water pan; water supply means for operatively supplying water into said pan; an evaporator; a water pump for operatively supplying water in said pan onto said evaporator allowing water to flow down along an outer wall of said evaporator; a guide member for guiding water back from said evaporator to said pan; refrigerant means for supplying to said evaporator a refrigerant in one of a compressed gaseous state and a condensed liquid state so as to operate said evaporator in either an ice-removing condition or a cooling condition, respectively; a heater for receiving an ice plate formed on and then released from said evaporator and for cutting the ice plate into lumps of ice so as to cause said lumps to fall down; a water level detector for generating a detection signal when a water level in said pan exceeds a predetermined high level, said detection signal being maintained until the water level falls below a predetermined low level; a power source; first switch means actuated while said detection signal lasts for connecting said power source to said pump so as to operatively actuate said pump; a thermostat provided on said evaporator and actuated when the temperature of said evaporator exceeds a predetermined high temperature at which ice can be removed from said evaporator, the actuation of said thermostat being maintained until the temperature of said thermostat falls below a predetermined low temperature at which ice can be formed; and second switch means actuated while said detection signal is not generated;

the improvement comprising:

a. a first ice detection switch actuated while said heater receives an ice plate thereon for operatively shunting said thermostat; and

b. a second ice detection switch connected in parallel to said thermostat and actuated while no ice plate exists on said heater;

said power source being connected in series to said refrigerant means through said second switch means and said first ice detection switch only while said second switch means and said first ice detection switch are concurrently actuated so that said refrigerant means operatively supplies to said evaporator the refrigerant in the gaseous state, and otherwise supplies the refrigerant in the condensed liquid state, and

said power source being connected to said water supply means through said second switch means and the parallel circuit of said thermostat and said second ice detection switch so that said water supply means operatively supplies water into said pan only while said second switch means and at least one of said thermostat and said second ice detection switch are concurrently actuated.

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