CONTROL SYSTEM FOR ICE-MAKING APPARATUS
Taisei Hosoda, Tochigi-ken, Japan, assignor to Hitachi Ltd., Tokyo, Japan, a corporation of Japan
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6 Claims. (Cl. 62—137)

ABSTRACT OF THE DISCLOSURE
A control system for ice-making apparatus having means for effecting positive, fully automatic and sequential switch-over control of a circulating pump, a solenoid valve for the change-over of the flow of a refrigerant, and a feed water valve. The control system can also positively operate in cooperation with a slow-acting thermostat.

BACKGROUND OF THE INVENTION
Field of the invention
This invention relates to ice-making apparatus, and more particularly to a control system for use in an ice-making apparatus of the type which is operated in such a way that a circulating pump takes suction of ice-making water from an ice-making water reservoir to supply the water to the surface of an evaporator in the refrigerating cycle so as to cause gradual freezing of the water on the evaporator surface, the operation of the circulating pump being stopped when a desired ice thickness is reached, and then the evaporator is heated by means of the so-called hot gas system which is so arranged as to directly lead a hot refrigerant gas from a compressor to the evaporator or by means of a heater or the like embedded in the evaporator to strip off the slab of ice from the evaporator surface.

SUMMARY OF THE INVENTION
It is an object of the present invention to provide a control system for an ice-making apparatus by which the whole operation including ice-making water feed, ice-making, strip-off of ice slab and subsequent ice-making water feed can be fully automatically carried out. Another object of the present invention is to provide a control system for an ice-making apparatus which can make a positive operation in cooperation with a slow-acting type of thermostat.

Other objects, advantages and features of the present invention will become apparent from the following detailed description of a preferred embodiment with reference to the accompanying drawings:

BRIEF DESCRIPTION OF THE DRAWINGS
FIG. 1 is a schematic circuit diagram of an embodiment of the control system according to the invention. FIG. 2 is a vertical sectional view of an ice-making apparatus equipped with the control system shown by the circuit diagram in FIG. 1. FIG. 3 is a schematic diagram of the refrigerating cycle employed in the ice-making apparatus shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT
Referring to FIG. 2, an ice-making apparatus equipped with the control system according to the invention is shown as including a thermally insulated liquid chamber which comprises a cabinet 27 having an upper wall 271, a rear wall 272, side walls 273, and a bottom wall 274, and two doors 281 and 282 air-tightly closing the front opening of the cabinet 27. The ice-making apparatus is provided with a water feed section, a water reservoir section, a water circulating section, a refrigerating section, an ice strip-off section, and an ice storage section.

The water feed section comprises a conduit 111 led from an external supply such, for example, as a city water supply to a water reservoir 29 disposed in the upper part of the closed chamber, and a feed water valve 11 inserted in the conduit 111 on its way to the water reservoir 29. The feed water valve 11 is equipped with an electromagnetic coil or solenoid (not shown) as to be electrically opened and closed as desired. A heater 12 of suitable capacity is embedded in that portion of the conduit 111 which is situated in the closed chamber.

The water reservoir section comprises the water reservoir 29 of material such as a synthetic resin which is suitably supported in the upper part of the closed chamber by supports (not shown). In the water reservoir 29, there is disposed a three-electrode plug 26 having three electrode rods 261, 262 and 263 of different lengths. The electrode rod 261, which is the shortest of all, is disposed intermediate between the other electrodes 262 and 263, and its lower end determines the highest water level, that is, the maximum amount of water to be stored in the water reservoir 29. In other words, ice-making water can be filled in the water reservoir 29 up to a level of the lower end of the electrode rod 261. The lower end of the second electrode rod 262 determines the intermediate water level, that is, the amount of water which remains in the water reservoir 29 after the ice-making has finished. Therefore, the difference between the lengths of the electrodes rods 261 and 262 determines the thickness of ice that can be made. In other words, the amount of ice that can be made is determined by the difference between the amount of ice-making water up to the level of the lower end of the electrode rod 261 and the amount of ice-making water up to the level of the lower end of the electrode rod 262.

The water circulating section comprises a circulating pump 15, a conduit 151 extending upwardly from the pump 15, and a water sprinker 152. The circulating pump 15 is operative to supply the ice-making water stored in the water reservoir 29 to the surface of an evaporator 50, as will be described later, for thereby causing freezing of the water on the surface of the evaporator 50. An unfrozen portion of the circulating water flows down into the water reservoir 29 for recirculation by the circulating pump 15 to the surface of the evaporator 50. The circulating pump 15 consists of a pump portion 15a submerged in the ice-making water and a drive motor 15b disposed thereabove. Upon operation of the pump 15, the ice-making water is taken suction from a suction port 15/ and is discharged from a discharge port 15e to be led to the water sprinker 152 by way of the conduit 151. The water sprinker 152 is disposed above one end of the evaporator 50 and has on its bottom formed with a multiplicity of spraying ports 15za bored in equally spaced relation. Thus, the ice-making water can be uniformly supplied to the surface of the evaporator 50 from these spraying ports 15za.

The refrigerating section is operative to cause freezing of the ice-making water flowing over the surface of the evaporator 50, and comprises an electrically driven compressor 8, a condenser 30, a capillary tube 40, the evaporator 50, and conduits 8b, 30a, 40a, and 50a connecting these elements to constitute a refrigerating cycle as shown in FIG. 3. A gas refrigerant at high temperature and high pressure discharged from the compressor 8 is led into the condenser 30, wherein the gas liquefies while releasing its heat to the exterior. The liquefied refrigerant is reduced in its pressure in the capillary tube 40 and is then evaporated in the evaporator 50 to return to the compressor 8. As is commonly known, the liquid refrigerant takes up ambient heat as it evaporates, and this
The compressing phenomenon is utilized to cause freezing of the ice-making water. The compressor 8 is disposed below the bottom wall 274 of the closed chamber, and the condenser 30 is disposed externally of the rear wall 272, while the evaporator 50 is inclined disposed above the water reservoir 29 with its rear end situated slightly forwardly of the rear end of the water reservoir 29. The size of the evaporator 50 has an important relation with the thickness of the slab of ice that can be made. More precisely, the difference between the lengths of the electrodes 261 and 262 determines the amount of ice that can be made, and the size of the evaporator 50 limits the thickness of the plate of ice so made.

The ice-strip-off section is operative to strip off the slab of ice frozen on the surface of the evaporator 50 from the evaporator 50, and supplies a solenoid valve 14 interposed in the conduit 8a, and a conduit 140 connecting the valve 14 to the evaporator suction conduit 40a to constitute a heating cycle as shown in FIG. 3, together with the compressor 8, the evaporator 14 and the interconnecting conduits 8a, 40a, and 50a. In the heating cycle, the gas refrigerant at high temperature and high pressure discharged from the compressor 8 is led through the solenoid valve 14 to the evaporator 50, and then returns to the compressor 8.

The ice storage section stores the cubic pieces of ice cut by lattice-like heater 6, and comprises a slider 60, an ice reservoir 70, and means for detecting the amount of stored ice. The slider 60 is disposed in a forwardly inclined relation beneath the rear end of the evaporator 50, and the lattice-like heater 6 is disposed above the slider 60, while the ice reservoir 70 is disposed beneath the heater 6. The ice cut into pieces by the lattice-like heater 6 and stored in the ice reservoir 70 can be taken outside by opening the door 282. The stored ice detecting means consists of a light projecting lamp 4 and a photoconductor 5 disposed opposite to the lamp 4.

Referring now to FIG. 1, the ice-making control system according to the invention will be described in detail. A main switch 1 is disposed at a position nearest to a power source connecting plug 37 in the circuit so as to effect electrical open-close control of all the elements as will be described later. The main switch 1 may preferably be a manual push button switch. The compressor 8 is connected to the plug 37 through an overheat thermostat 2 mounted on the lower face of the evaporator 50, and a movable contact 71 and a stationary contact 72 of a relay 7. The overheat preventative thermostat 2 is normally closed and is urged to its open position by the self-heating in the event that an overcurrent flows therethrough. The relay 7 is arranged to receive its power supply through a power transformer 3.

More precisely, the relay 7 is connected with a secondary winding 32 of the power transformer 3 in series with the photoconductor 5, such as cadmium sulfide (CdS) whose resistance varies when illuminated by lights, a semi-fixed resistor 19 for resistance compensation, and a rectifying diode 18. The relay 7 is so set that its contacts 71 and 72 are closed when it is energized due to the fact that the photoconductor 5 is illuminated by the light from the light projecting lamp 4, as will be described later. The primary winding 31 of the power transformer 3 is connected through the main switch 1 to the connection plug 37. The light projecting lamp 4 disposed opposite to the photoconductor 5 receives its power supply from an intermediate tap of the secondary winding 32 of the power transformer 3. The lattice-like heater 6 also receives its power supply from another intermediate tap of the secondary winding 32 of the power transformer 3.

The feed water valve 11, solenoid valve 14 and circulating pump 15, and hence the compressor 8 is controlled independently of these elements. The feed water valve 11 is connected in parallel with the heater 12 and a relay 13. The parallel circuit of the feed water valve 11, heater 12 and relay 13 is connected with the power supply through a slow-acting thermostat 17 such as a bimetal switch which operates by detecting the surface temperature of the evaporator 50. The slow-acting thermostat 17 consists of a temperature-sensitive movable bar 171 and a stationary contact 172, and is adapted to close at 15°C and open at 5°C in the present embodiment. The slow-acting thermostat 17 is connected in parallel with contacts 131 and 132 of the relay 13 which are closed when the relay 13 is energized.

The series circuit consisting of the slow-acting thermostat 17 and the parallel circuit of the feed water valve 11, heater 12 and relay 13 is connected in parallel with the solenoid valve 14 through contacts 131 and 133 of the relay 13 which are closed when the relay 13 is energized. The series circuit consists of the solenoid valve 14 and a relay 9 connected in parallel with the parallel circuit of the feed water valve 11, heater 12, relay 13 and solenoid valve 14 so that if these movable contact 91 and the contact 93 of a relay 9 directly connect the circulating pump 15 to the power supply, while closure of the movable contact 91 and a contact 92 of the relay 9 cut off the circulating pump 15 from the power supply. The relay 9 is so set that its movable contact 91 is brought into contact with its contact 93 when the relay 9 is energized. The relay 9 is adapted to be energized through contacts 101 and 102 of a relay 10, while the relay 10 is adapted to be energized through contacts 161 and 162 of a relay 16. The contacts 101, 102, and 161, 162 are so arranged as to be opened when the respective relays 10 and 16 are deenergized. The relay 16 is connected to the secondary winding 32 of the power transformer 3 through rectifying diodes 21 to 24 and a smoothing condenser 25, and further through the electrode rods 261, 262, and 263. Contacts 94 and 95 of the relay 9 are connected in series with the electrode rod 262 and the relay 16.

The control system for the ice-making apparatus having the structure as described above operates in a manner as described below for the automatic production of cubic pieces of ice.

At first, the connection plug 37 is connected to the power supply and the main switch 1 is turned on. The power transformer 3 is thereby energized and the light projecting lamp 4 is lit to illuminate the photoconductor 5. If, in this case, cubic pieces of ice are not or only insufficiently stored in the ice reservoir 70, the resistance of the photoconductor 5 is reduced by the increased illumination from the lamp 4, and an increased flow of current through the relay 7 energizes the relay 7 to thereby close its contacts 71 and 72. The closure of the contacts 71 and 72 completes a circuit including the connection plug 37—main switch 1—electrostatically driven compressor 8—contact 71 meanwhile energizing the connection plug 37, so that the operation of the refrigerating cycle is started. It will thus be understood that the operation of the refrigerating cycle is automatically started only when the necessary detection of the amount of ice stored in the ice reservoir 70 has found that cubic pieces of ice are insufficiently stored therein. The refrigeration cycle is automatically stopped when a predetermined amount of stored ice has been reached, as described later.

In case the ice-making water in the water reservoir 29 is stored up to the level of the lower end of the electrode rod 261 at the beginning of the refrigerating cycle, current is supplied to the relay 16 from the secondary winding 32 of the power transformer 3 through the electrode rods 263 and 261 and the ice-making water. Energization of the relay 16 closes the contacts 161 and 162 to energize the relay 10. Energization of the relay 10 closes its contacts 101 and 102 to energize the relay 9, with the result that the movable contact 91 of the relay 9 is brought into contact with the contact 93. Closure of the contacts 91 and 93 completes a circuit including the connection plug 37—main switch 1—contact 91—contact 93—circulating pump 15—contact 72.
71—thermostat 2—connection plug 37, so that the circulating pump 15 starts its operation. In case the ice-making water in the reservoir 29 is not filled up to the level of the lower end of the electrode rod 261 at the beginning of operation of the electrically driven compressor 8, the relay 16 would not be energized and hence the relay 9 would not be energized because the contacts 94 and 95 of the relay 9 are held open even if the electric current valve 11 is energized. With the result the ice-making water supply is cut off by the contact 91 of the relay 9. As a result, the movable contact 91 of the relay 9 is urged to its closed state with the stationary contact 92. Since, in this case, the movable bar 171 of the thermostat 17 is in contact with the stationary contact 172, a circuit including the connection plug 37—contact 91—contact 92—feed water valve 11—contact 172—movable bar 171—contact 72—contact 71—thermostat 2—connection plug 37 is completed so that the supply of ice-making water to the water reservoir 29 is started. It will thus be understood that the water supply is automatically started only when the necessary detection of the amount of water stored in the water reservoir 29 has found that water is insufficiently stored in the water reservoir 29. The feed water supply is automatically stopped when a predetermined level of water has been reached, as will be described later.

The relay 13 connected in parallel with the feed water valve 11 is energized in simultaneous relation with actuation of the Solenoid 15 as described 11, and as a result, its movable contact 131 is urged away from its closed state with the contact 132. Therefore, the solenoid valve 14 is not energized and the compressor 8 is placed in its operation in the refrigerating cycle. That is to say, the feed water supply is started by the action of the thermostat 17 and the relay 13 after detection of the amount of water stored in the water reservoir 29 and after subsequent ascertaining of non-necessity of the heating cycle. Since the movement of the movable contact 131 of the relay 13 away from the contact 133 interrupts power supply to the solenoid valve 14 and at the same time the closure of the contacts 131 and 132 provides a path of current bypassing the thermostat 17, a circuit including the connection plug 37—main switch 1—contact 91—contact 92—feed water valve 11—stationary contact 132 of relay 13—movable contact 131 of relay 13—contact 72—contact 71—thermostat 2—connection plug 37 is completed to energize the solenoid valve 14 and the relay 16 for the circulating pump 15. The ice-making water fed to the water sprinkler 152 uniformly flows down onto the evaporator 50, with a portion of the water freezing onto the surface of the evaporator 50 and the remaining portion draining down into the water reservoir 29. By the repetition of the above operation, the thickness of the slab of ice on the surface of the evaporator 50 becomes successively large, while on the other hand, the ice-making water in the reservoir 29 gradually decreases and its water level is successively lowered. Even with the absence of the short circuit between the electrode rods 261 and 263, the relay 16 is energized through the movable contacts 94 and 95 of the relay 9 and the short circuit between the electrode rods 262 and 263, and thus the circulating pump 15 is also continuously operated. When the short circuit between the electrode rods 262 and 263 by the ice-making water is no more present due to the lowering of the water level by the continuous operation of the circulating pump 15, that is, when the slab of ice on the surface of the evaporator 50 reaches a predetermined slab thickness, the relay 16 is deenergized to deenergize the relay 10 for thereby causing deenergization of the relay 9, and as a result, the movable contact 91 of the relay 9 moves away from its previous contact with the contact 93 and is now brought into contact with the contact 92. This causes stoppage of the circulating pump 15. On the other hand, the evaporator 50 is sufficiently cooled down and the thermostat 17 is in its open position. Therefore, a circuit including the connection plug 37—main switch 1—contact 91—contact 92—solenoid valve 14—contact 133—contact 131—contact 72—contact 71—thermostat 2—connection plug 37 is completed to energize the solenoid valve 14. It will thus be understood that the amount of ice produced is automatically detected to stop when the ice-making water has reached a predetermined amount of ice is made, and then the solenoid valve 14 is operated.

The refrigerating cycle is thus switched over to the heating cycle for stripping off the slab of ice from the surface of the evaporator 50. The stripped plate of ice slides and drops off the inclined evaporator 50, and is...
The cubes of ice drop onto the slide 60 and thence into the ice reservoir 70 for storage therein. The temperature of the evaporator 50 makes an abrupt increase as soon as the slab of ice is stripped off the evaporator 50. The thermostat 17 is urged to its closed position when the temperature of the evaporator 50 exceeds 15°C. A circuit including the connection plug 37—main switch 1—contact 91—contact 92—relay 12—stationary contact 172—movable bar 171—contact 72—contact 71—thermostat 2—connection plug 37 is completed to urge the movable contact 131 of the relay 13 away from the contact 133 and into contact with the contact 132. Accordingly, the operation of the solenoid valve 14 is automatically stopped and the heating cycle is switched over to the refrigerating cycle. Current is again supplied to the feed water valve 11 and the heater 12 so that the whole system is restored to its original state.

From the foregoing description, it will be understood that the movable contact 91 of the relay 9 is urged into contact with the contact 92 to supply current to the feed water valve 11 and at the same time to supply current to the relay 13 for thereby urging the movable contact 131 of the relay 13 away from its closed state with the contact 133 in the circuit of the solenoid valve 14 and bringing into contact with the contact 132 to establish a current path bypassing the thermostat 17 and to effect feed water supply by the feed water valve 11. Then, the movable contact 91 of the relay 9 is urged away from the contact 92 and is brought into contact with the contact 93 to effect the ice-making through water circulation by the circulating pump 15. Thereafter, the movable contact 91 of the relay 9 is urged away from the contact 93 and is brought into contact with the contact 92 to energize the solenoid valve 14 for hot gas supply for effecting the strip-off of the slab of ice from the evaporator 50, with the thermostat 17 in its open position. Finally, the thermostat 17 is urged to its closed position to cooperate with the feed water valve 11 and the relay 13 to start the supply of feed water again. In this manner, the operation of ice-making water feed, ice-making strip-off of ice, and subsequent ice-making water feed is repeated so that the amount of ice cubes stored in the ice reservoir 70 is gradually increased.

When a predetermined amount of ice is accumulated in the ice reservoir 70, the photoconductor 5 having energized the relay 7 due to the fact that its resistance is reduced by being illuminated by the light projecting lamp 4, hardy receives the light from the lamp 4 because the light from the lamp 4 is absorbed or subject to diffused reflection by the ice which intercepts the path of light. As a result, the resistance of the photoconductor 5 becomes large since the electrical resistance of the photoconductor 5 is variable depending on the brightness, that is, the energy of absorbed light. Due to the large resistance of the photoconductor 5, the relay 7 is deenergized to open the contacts 71 and 72. The opening of the contacts 71 and 72 interrupts the power supply of the compressor 8, feed water valve 11, solenoid valve 14 and circulating pump 15 to thereby stop the operation of these elements. These elements are therefore held in their non-operating state until the light from the lamp 4 is directly projected onto the photoconductor 5 because of a situation that the ice cubes lying in the path of light from the lamp 4 to the photoconductor 5 are removed for services by the user of the ice-making apparatus or the ice cubes stored in the ice reservoir 70 are molten due to shutdown of the compressor 8 for a long period of time. Thereafter, the path of light from the lamp 4 to the photoconductor 5 is again illuminated by the light from the lamp 4 to the photoconductor 5 again because of the ice cubes stored in the ice reservoir 70. Accordingly, the system is restored to its initial state as a result of the operation of the relay 9 to supply current to the feed water valve 11 and the heater 12.
tionary contact electrically connected to one terminal of a below-mentioned circulating pump, and a movable contact connected to said first stationary contact when the water in said water reservoir decreases below a predetermined water level and urged into contact with said second stationary contact when the water in said water reservoir is filled up to the predetermined level, and a circulating pump electrically connectable with the source of power supply through the longest electrode and the next longer electrode of said electrode group, a third relay having a first movable contact and a first stationary contact which are closed in response to energization of said second relay to establish a current path through the next longer electrode of said second stationary contact connected to one terminal of the parallel circuit of said feed water valve and said solenoid valve, a third stationary contact electrically connected to one terminal of a below-mentioned circulating pump, and a second movable contact urged into contact with said second stationary contact in response to deenergization of said second relay and urged into contact with said third stationary contact in response to energization of said second relay, and a circulating pump electrically connectable with the source of power supply through said second movable contact and said third stationary contact of said third relay.

5. A system for controlling the operation of an ice-making apparatus provided with an openably closed cabinet, a refrigerant compressor, an evaporator, a condenser, a water reservoir and an ice reservoir; said control system comprising a slow-acting thermostatic operation by sensing the temperature of said evaporator, a feed water valve electrically connected to a point intermediate between it and said thermostat, a second stationary contact electrically connected to one terminal of a below-mentioned circulating pump, and a movable contact urged into contact with said first stationary contact when the water in said water reservoir decreases below a predetermined water level and urged into contact with said second stationary contact when the water in said water reservoir is filled up to the predetermined level, and a circulating pump electrically connectable with the source of power supply through the longest electrode and the next longer electrode of said electrode group, a third relay having a first movable contact and a first stationary contact which are closed in response to energization of said second relay to establish a current path through the next longer electrode of said second stationary contact connected to one terminal of the parallel circuit of said feed water valve and said solenoid valve, a third stationary contact electrically connected to one terminal of a below-mentioned circulating pump, and a second movable contact urged into contact with said second stationary contact in response to deenergization of said second relay and urged into contact with said third stationary contact in response to energization of said second relay, and a circulating pump electrically connectable with the source of power supply through said second movable contact and said third stationary contact of said third relay.
to one terminal of a below-mentioned solenoid valve, and a movable contact urged into contact with said first stationary contact in response to energization of said first relay for thereby establishing a current path bypassing said thermostat and urged into contact with said second stationary contact in response to deenergization of said first relay, a solenoid valve electrically connected through said second stationary contact and said movable contact of said first relay to a source of power supply and connected in parallel relation with the series circuit of said thermostat and said feed water valve, a second relay having a first stationary contact connected to one terminal of the parallel circuit of said feed water valve and said solenoid valve, a second stationary contact electrically connected to one terminal of a below-mentioned circulating pump, and a movable contact urged into contact with said first stationary contact when the water in said water reservoir decreases below a predetermined water level and urged into contact with said second stationary contact when the water in said water reservoir is filled up to the predetermined water level, a circulating pump electrically connectable with the source of power supply through said movable contact and said second stationary contact of said second relay and connected in parallel with said compressor so as to be controlled independently of the operation of said compressor, a pair of contacts disposed in the circuit to the source of power supply in order to disconnectably connect said feed water valve, said first and second relays, said solenoid valve and said circulating pump to the power supply, a photoconductor whose resistance is variable by being illuminated by light, a lamp disposed opposite to said photoconductor for directing a beam of light toward said photoconductor, and a third relay connected in series with said photoconductor so that its energization and deenergization can close and open said last-mentioned contacts.

References Cited

UNITED STATES PATENTS

2,995,905  8/1961 Ayres et al. 62—344

ROBERT A. O'LEARY, Primary Examiner.
W. E. WAYNER, Assistant Examiner.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,367,128
February 6, 1968

Taisei Hosoda

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

In the heading to the printed specification, after line 6, insert -- Claims priority, application Japan, July 20, 1966, 47,035/66 --.

Signed and sealed this 1st day of April 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents